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ART. XXXII.—*On the Electrotyping Operations of the U. S. Coast Survey;* by GEORGE MATHIOT, Electrotypist: being a Report to Major I. I. STEVENS, Assistant in charge of the Coast Survey Office.* With a Plate.

IN compliance with your request, I present the following report of the electrotype art as now practised in this office. Most of the apparatus and processes here used are entirely new.

To clearly exhibit the advantages derived from their introduction, it will be necessary to consider the scientific principles involved in their use, and also to take a cursory view of the history of the electrotyping art.

The art of working metals by electric currents is of very recent introduction; and although it has advanced with great rapidity, it is yet, perhaps, in a state of infancy in its applications, and of crudeness in the modes of conducting it.

The electro-deposition of metals was observed by most experimenters with the voltaic battery. As early as 1804 electro-gilding had been successfully practised; but the idea of making castings by electric currents does not seem to have occurred to any one previous to the introduction of Daniel's battery, to which electro-casting is incidental.

After the introduction of Daniel's battery, it simultaneously occurred to several persons that electric currents might be used

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to make castings of a finer kind than were obtained by melting and pouring. Propositions to this effect are about all that can be attributed to the rival claimants for the invention of electro-metallurgy; for neither the English nor Russian philosopher revealed what had not been known before.

Yet to Jacobi and Spencer is due the merit of having called public attention to the subject; for in doing this, they have conferred benefits on the world greater, perhaps, than by making an original discovery.

After the publications of Jacobi and of Spencer had called the attention of the scientific world to the new art, the principles involved in it became the study of several eminent philosophers, who disclosed the methods to be followed for obtaining reguline metal. After this, several departments of electro-metallurgy rapidly advanced. Electro-plating, and the multiplication of pages of letter-press work, as pages of type, and wood-cuts, (electro-stereotyping,) were soon extensively practised; but the copying of the delicate touches of the copper-plate engraver (the electrotype proper) was beset with difficulties. On account of the great value of the engraved plate, together with the risk of its being detroyed in the attempt to copy it, and the uncertainty as to whether the duplicate would have good metallic properties, even if the operator should have the good fortune to obtain one, this department of the art, (the first and most beautiful of Spencer's suggestions,) was allowed to rest as an experiment or be confined to articles of small size and value.

Adhesion of deposite to matrix.—Electro-metallurgy requires that the deposited metal should have all its cohesive properties. If such a deposit of copper is made on a clean plate of copper, it is obvious that the deposited metal will cohere with the plate on which it is made, and an elaborately engraved plate would thus be converted into a mere mass of metal. The electrotype art, therefore, cannot exist before means are provided for preventing this destructive adhesion.

Various plans for overcoming this difficulty have been proposed. All these, however, have a common feature, which is to prevent the deposit and matrix from touching by means of an intervening film of heterogeneous matter.

Mr. Smee proposes to use that coating of air which adheres so firmly to polished metals, (so strikingly exhibited when the attempt is made to wet a polished knife-blade.) To obtain the air coating, he directs that, after every attachment has been made to the plate, it be placed in a cool and moist cellar for a few days before introducing it into the electrotype vat.

Smoke, black lead, oils, and powders, and wax, have also been proposed for covering the face of the plate.

The method used in the British ordnance survey is perhaps the best of all these. This is conducted as follows: The plate is first well oiled, and the oil well wiped away with soft bread. The plate is then heated to above the temperature of melting wax, and a cake of white wax pressed against the edge. The oil having removed the air from the plate, the wax will flash over it in an extremely thin sheet or film. All excess of wax is then to be wiped away with a fine linen cloth, free from lint. The plate must be left to cool before introducing it into the vat.

To smear the face of the finely engraved plate is in opposition to the fundamental idea of the electrotype, which is that of atomic casting. In the process of Mr. Smee, air bubbles will be retained in the fine lines of the graving, thus mutilating the copy; moreover, the face of the new plate is waved from the agitation of the stratum of air when receiving the first portion of copper.

In the waxing process it is almost impossible to free every line from excess of wax. Even days of tedious application do not insure perfection. In addition to the coarseness of these various methods, they are extremely uncertain as to whether they effect the purpose for which they are applied.

It was always observed that if the deposited metal was *not deficient* in mechanical properties, it stuck very hard to the original, and the plates had to be subjected to violent jarring, heating and beating, to separate them. But if the deposited metal was of very fine quality, then most likely the deposit was *inseparably* united to it. From these circumstances attending the adhesion of the deposit, it occurred to me that, when the cohesive force was but feebly developed in the deposited metal, then the force of cohesion or homogeneous attraction could not extend the distance presented by the thickness of the film of heterogeneous matter between the plates; but that when these forces were well developed, the spheres of homogeneous attraction of each plate would extend through the wax or air film.

It may be proper here to remark that the above views of adhesion have been applied to another department of electro-metallurgy with the most gratifying success. In electro-plating the difficulty of obtaining a firm adhesion of the film of precious metal is entirely obviated by making such arrangements as insure a rapid deposition of highly ductile metal at the moment the article to be plated is immersed in the electrolyte.

In considering the sticking of the plates, after homogeneous attraction or cohesion, heterogeneous attraction or adhesion demands attention; for two similar bodies may be separated by a film of heterogeneous matter, which binds them more firmly together than their particles are held together by cohesion, as we see in the use of cements.

This force is very powerful between some bodies, while between others it is very slight. Air adheres very strongly to metals, as before referred to; hence a film of air may unite two copper plates, even though they are separated beyond the distance at which cohesive attraction takes place.

Wax is a common ingredient in cements; its adhesive properties have become proverbial; its use is evidently improper. Therefore a substance having a strong adhesive attraction for the plates must not be on the face, and the cohesive force of the surface particles must be suspended by other methods than making the deposited metal deficient in mechanical properties.

It was hoped that a substance could be found that would act uniformly and gently on the surface of the engraved plate, and which in destroying the homogeneous attraction of the surface particles, would, by chemical union with them, form an insoluble and friable compound, having but a slight adhesion to the plate. I was led to select iodine for the experiment on account of its sparing solubility in water, its high equivalent number, and innoxious qualities. A copper plate was well cleaned, exposed to the vapor of iodine, and electrotyped; the deposit separated from it readily. This was repeated some hundred times with invariable success.

It was found, in cleaning large plates for the application of the iodine vapor, that while one part of the plate was being cleaned, another part would tarnish, and hence a uniform action of the iodine could not be obtained. This led to silvering the plates before iodizing, which facilitated the cleaning and exhibited the action of the halogen. A silvered plate was washed with an alcoholic solution of iodine and electrotyped; the electrotype separated from the matrix yet more readily than before, the iodid of silver serving better to prevent adhesion than the iodid of copper.

But it was soon observed that a plate prepared on a dull day did not separate so readily as one prepared under a bright sky, and on experimenting it was found that a plate iodized and exposed to sunshine would separate with very great facility; while a plate iodized on a rainy day, and placed in a dark room for a few hours before introducing it into the vat, might stick so hard as to require some of the old resorts of heating and jarring to separate it from the matrix.

The process of iodizing and exposing to light has now been applied to a very great extent of finely engraved surface, and in no case has the least difficulty been found in lifting one plate off the other when the requisite thickness had been obtained.

I am aware that it may be thought that the iodine acts only by intervening between the plates; but the quantity of iodine applied to a plate must be thought insufficient to effect it by mere mechanical separation when we consider the large quantity

of silex and carbon found in ordinary copper. If but one ounce of copper be dissolved from a square foot of ordinary plate, a very heavy deposit of impurities is left, (sometimes 5 per cent.) and the quantity of wax which may be applied to a plate, and fail to prevent sticking, is ten thousand times more than the quantity of iodine which prevents it.

In preparing our largest plates, having ten square feet of face, I use a solution of one grain of iodine in twenty thousand grains of strong alcohol. If one grain of the solution is required to wet a square foot, it will give but $\frac{1}{20000}$th of a grain of iodine on a square foot. But as the iodine evaporates rapidly with the alcohol, probably the actual quantity on a square foot does not exceed one-hundred-thousandth part of a grain.

Taking the weight of a cubic inch of iodine at 1,250 grains, and supposing that it remains on the silver surface in its elementary state, instead of forming iodid of silver, then we have $1{,}250 \times 144 \times 100{,}000 = 18{,}000{,}000{,}000$, only one-eighteen-thousand-millionth part of an inch for the thickness of the coating of iodine. Even if we suppose that the solar rays decompose the iodid of silver, and leave the iodine in vapor on the plate, it will still be only one-forty-four-millionth part of an inch—a thickness to be taken as nothing in a mechanical view.

To test the effect of the chemical method of preventing adhesion on the sharpness of the engraved lines, an engraving was seven times successively transferred from plate to plate, when the closest inspection failed to show any inferiority of impressions from the last plate as compared with those from the first.

Time and expense of electro-casting.—Next in importance to securing a certain and easy separation of the matrix and casting is bringing the entire time and expense of electrotyping within the narrowest limits.

Mr. Smee and others have shown that the quality of electro-metal is determined by certain relations between the rapidity of forming the plate and the strength of the solution in which it is formed. Both the common operations of the electro-metallurgist, and the improvements he proposes, must conform to these relations.

As small quantities of electricity are easily set in motion, small-sized electro-castings are readily made in six or eight days. To make large castings in a short time requires a powerful current. To accomplish the corresponding augmentation in the effective electric action has proved a somewhat difficult matter.

At the date of the "Aide Mémoire to the Military Sciences," it is stated that in the ordnance survey one pound of copper was deposited in twenty-four hours on a plate of eight square feet, the plates being made ductile enough to bear hammering only by continued agitation of the electrolytic solutions.

At this rate, to make a plate one-eighth of an inch thick will require forty-five days. So far as I am informed, the above performance has not been excelled, as to quality and time, on large work anywhere prior to its being attained as now to be described.

The first and most obvious suggestion for increasing the rate of deposition is to enlarge the battery; this, however, is incapable of producing the desired end.

To present this subject in a clear and satisfactory manner, I will make use of the celebrated formula of Professor Ohm, who deduced from mathematical reasoning, and established by experiment, that the effective force of the current from any battery was directly as the electromotive force, and inversely as the resistance offered to that force.

To express this, he gave the equation $\frac{E}{R+r}=Q$, in which E represents the electromotive force, or affinity of acid for zinc, and $R+r$ the resistance to the current generated by that force; R representing the resistance offered to it from the liquid contained between the positive and negative elements of the battery, and r the resistance offered by the object on which the battery is working, and Q the amount of work executed, or the quantity of the current obtained.

The resistance of conductors has been found to be directly as the length, and inversely as the section.

So far as concerns form of arrangement, E is constant for the materials used, as it depends on their chemical relations, Q can therefore be favorably affected only by varying R or r. Now, as R represents the resistance of the liquid contained between the battery plates, to increase the size of the plates is only to increase the section of the liquid, or, in other words, to diminish the resistance represented by R. The expression, $\frac{E,}{R+r}=Q$, shows that, if the resistance in the battery is small compared to the external resistance, the gain of effect from enlarging the battery plates is but small.

To determine the relative value of R, as compared with r, a battery was constructed so as to collect and measure the gas evolved by its action.

The plates were placed in contact with each other, and the gas evolved in thirty minutes taken as a unit of effect. As in this case the current did not pass through anything but the battery, there is no resistance to be represented by r, or r in the formula will be equal to 0 and $Q=\frac{E}{R}=1$.

The battery was then attached to a pair of electrodes, in a certain solution of sulphate of copper and sulphuric acid, espe-

cially recommended by all the writers on electro-metallurgy, the arrangement being such as to produce good metal. The gas now evolved in thirty minutes was found only one-twentieth of the former amount; hence the introduction of the resistance, r, had diminished Q twenty times, and $\frac{E}{R+r}=Q=\frac{E}{20\,R}$, whence r is equal to 19 R. To exhibit the effect of battery enlargement, we now have $Q=\frac{1}{\frac{1}{m}+19}$. If $m=1$, then $Q=\cdot05$; if $m=2$, $Q=\cdot0512$; if $m=3$, $Q=\cdot0518$; if $m=4$, $Q=\cdot0524$, &c., &c. This shows a gain of only a fortieth from doubling the size of the battery, &c.—an advantage too small to repay for the enlargement. These calculations are in accordance with experimental results from small batteries, but in large ones the necessity of further separating the plates, in increasing their size, makes the resistance increase, instead of diminish, and there is consequently a loss from enlargement. It is not, therefore, by merely increasing the battery surface that the time for electrotyping can be shortened.

Mr. Smee, the distinguished writer on electro-metallurgy, by covering the negative plate of the battery with pulverulent platinum, produced a very energetic form of the instrument. When the plate is freshly platinized, it acts violently, and throws off the hydrogen in torrents. But this increased energy of the plate is gradually lost, from the electric current depositing upon it impurities from the zinc.

As this deposit has a strong attraction for the hydrogen, it is retained on the plate. The plate, being thus encased in air, is virtually excluded from the liquid of the battery. The ordinary solvents of the metals do not readily remove this coating of impurity. The plate can be renewed by replatinization; but, as this is both tedious and expensive, I was urged to find a menstruum which would restore the original platinum to its energy. This I attained, at length, by immersing the plate in a solution of per-chlorid of iron, which almost immediately restores the action of the plate.

The plates are now daily immersed in the chlorid of iron, by which the tone of the battery is constantly maintained.

By this last discovery, together with obtaining better solutions for the decomposing cell, the time for making a casting was reduced; but still the time required for making a plate was too long when only one electrical equivalent was employed.

The effective force of one battery may be added to another. This is increasing E in the formula, and this will sometimes increase Q.

We unite the effective force of many batteries by joining their dissimilar ends in consecutive order. As the current in such an

arrangement has to traverse every battery in the chain, R will be multiplied as many times as we multiply E. The formula then becomes $Q=\frac{n\,E}{n\,R+r}$. When the value of r and R are nearly equal, and we have batteries of definite construction to work with, it becomes a matter of some importance to determine whether we shall use the whole galvanic apparatus, as a single electrical equivalent, by connecting all the similar parts of all the battery cells, or whether we shall convert it into a battery of two pairs, in consecutive order, by joining dissimilar ends. As dividing the battery is doubling R, and to double the electrical equivalents is also to double R, we shall increase R fourfold by the double arrangement. Instead of $Q=\frac{E}{R+r}$ we have $Q=\frac{2\,E}{4\,R+r}$. Taking $R=r$ we have $Q=\cdot 50$ in the single arrangement, and $Q=\cdot 40$ in the double—showing that we may double the expense, and yet make the casting more slowly than before. Conditions as above are of frequent occurrence, and a knowledge of them without experimenting is of very great importance.

For $R=10\,r$, with a single equivalent of battery, $Q=\frac{1}{1+10}=0{\cdot}0909$. For two batteries in series $Q=\frac{2}{2+10}=0{\cdot}166$. The use of two batteries in consecutive order, as thus exhibited, doubles the expense, but does not double the effect. A regard for economy prohibits us from further increasing the series. To represent an effect double of $\frac{E}{R+r}$ we have $2\left(\frac{E}{R+r}\right)=\frac{2\,E}{\frac{2\,R+r}{2}}$. As dividing R by 2 is doubling the battery surface, we may now make $Q=\cdot 183$. The gain per cent., now indicated by doubling the surface, makes it advantageous to make this increase when two consecutive batteries are used.

The difficulty of obtaining large flat plates of silver proved a serious obstacle in effecting an increase of battery surface, for the irregularity of the surface requires the plate to be placed at an increased distance from the zinc, thereby augmenting R, the very thing sought to be diminished.

Plates could be made flat by the planishing hammer; but the operation being expensive, and the plates continually liable to accidents in use, economy prohibited this mode of forming flat plates. Though the plating of metallic bodies with silver had been well executed, it had not yet been determined that electro-casting of silver could be executed in a desirable manner, and at a moderate expense and trouble. At first, every attempt to make

plates weighing 2,500 grains to the square foot failed, on account of the impossibility of observing Mr. Smee's laws of electro-metallization for the time required.

But after modifying the solutions of silver, and using a register battery, a plate could be made in thirty hours, perfectly flat, and possessing the mechanical qualities of hardness, elasticity, and malleability, in an eminent degree, and not costing over 16 cents per ounce for the making.

The perfectly flat plates admit of a very close approximation to the zincs. Their size may therefore be increased to more than twice their former surface, as in the double arrangement, r is relatively smaller to R.

Important changes have also been made in the modes of operating, and in the arrangement of the apparatus. It had early been noticed that changes of temperature influenced the rate of working; and every electro-metallurgist knows the importance of keeping the laboratory warm.

To determine where and how the effect of temperature took place, a battery, at 60 degrees Fahrenheit, was connected with a wire 120 feet long, and enclosing a galvanometer. The deflection was 40 degrees; the battery was then cooled until the temperature was 48°; the needle was still deflected nearly 40 degrees.

This experiment indicated that the batteries were not greatly affected by ordinary variations of temperature. Advantage was then taken of this development to secure a more perfect ventilation. Accordingly, a small room, to contain the battery, was partitioned off from the general apartment by a glass partition, and large outward openings made at the top and at the bottom of the room, to give a circulation of air for carrying off the battery fumes.

At the stage of improvement now described, one of our medium plates, having eight square feet of surface, could be readily made in from eight to ten days. But wishing still further to quicken the process, or attain my first desire—to deposit one pound per day on the square foot, with a single equivalent of battery—improvements were again sought after. As the E of the formula has been increased to the greatest extent the cost would permit, and R had been diminished, or the plates increased in size to the greatest useful extent, it was sought to increase Q by diminishing r, or the electrolytic resistance. It was sought to increase the conducting power of the electrolyte by adding easily decomposable salts to it; but with no success. The accelerating effect of temperature being found, as above stated, to be confined chiefly to the decomposition cell, it was evident that by using the electrolyte alone, at a high temperature, a considerable advantage might ensue.

To determine the most advantageous working temperature, and the resulting gain of effect, a voltameter battery was connected to a pair of electrodes, in the solution formerly described as being generally recommended. Each electrode had five square inches of face, and was coated on the back to prevent radiation. They were placed one inch apart, and had thin plates of wood bound against their edges, to prevent any lateral spread of the current in passing between them. The following was then obtained:

Battery plates in contact	gave	300	cubic inches	gas	per hour.	
Electrodes in contact	do.	216	do.	do.	do.	
Current through electrolyte, at	58°,	gave	16	cubic in.	gas per h.	23·15
do. do.	60°	do.	20	do.	do.	18·15
do. do.	100°	do.	27	do.	do.	13·00
do. do.	175°	do.	37	do.	do.	8·96

The last column of figures shows the value of the resistance of the solution, as compared with R of the formula. This column was obtained by first uniting the battery plates, and afterwards the electrodes.

From the above table it appears that heat may be made to diminish the resistance in the decomposition cell in the proportion of 2·58 to 1; and the whole resistance by 2·25. And as $\frac{2\,E}{R+r} = \frac{E}{\frac{R+r}{2}}$; therefore, by heating the electrolyte, we may with a single electrical equivalent make a plate as rapidly as by working at atmospheric temperatures with two batteries in consecutive order, with double surfaces, (four times the battery and twice the expense.)

But as Smee's laws require that, in forming a plate, certain mutual conditions of apparatus be maintained, it follows that alterations in one element or condition must be attended by corresponding changes in the others. Hence, if the temperature of the electrolyte be raised to a certain point, and the apparatus correspondingly adjusted, it is evident that, to avoid incessant adjustment, the original temperature must be maintained.

Thus, to avail ourselves of the advantages experimentally found from heating the solutions, an apparatus for steadily maintaining a high temperature in the electrolyte through several successive days becomes indispensable.

As the electrotype operations are not suspended at night, it is important that the heating apparatus should perform its office for at least twelve hours without supervision or replenishing its fuel; and its action should be sensibly uniform, during all the time, between successive replenishings.

Such an apparatus I have devised, and is now in use. A peck of charcoal furnishes fuel for twelve hours, and maintains 100 gallons of copper solutions steadily, at any required point between 100° and 200°.

With the above arrangement in use, I have made a large reverse or alto, and returned the original to the engraving department in 55 hours from its being placed in my hands. This time included trimming the edges and the preparations to prevent adhesion.

Again recurring to Ohm's formula, the relative value of R to r was once more experimentally found. This gave $R : r :: 1 : 4$ or $Q = \frac{1}{1+4} = 0{\cdot}20$, a great improvement as compared with the first determination of $R : r :: 1 : 19$, or $Q \frac{1}{1+19} = 0{\cdot}05$. * Having now made r so small compared with R, the size of the battery can be profitably increased until the result is about 0·24. Moreover, using a double arrangement of cells with double surfaces, for a double effect, we now have $2\left(\frac{1}{1+4}\right) = \frac{2}{2+4} = 0{\cdot}40$. As the relative resistance of the electrolyte becomes now still smaller, we may yet more increase the battery surface until the result is nearly 0·5.

The electrotype has now ceased to be a mere experiment, uncertain, expensive, and slow. I have lately formed plates of most excellent quality, at the rate of three pounds to the square foot, in 24 hours. This rate will require but two days to form one of our largest plates, having ten square feet surface, and one-eighth of an inch thick.

Actions in the electrolytic solution.—The quality of the deposited metal is governed solely by the relations between the *quantity* of the electricity passing through any solution and the amount of metal the solution contains. The usual supposition is, that the acid of the salt goes to one electrode and the metal to the other, but it is now ascertained that no such mutual transfer takes place; for, while the acid is carried to the positive electrode, the metal is *not* carried to the negative electrode. Hence, however strong the solution on commencing the process, the negative electrode, by abstracting the metal in its vicinity, is soon surrounded with a weak solution. With a simple wire electrode, the exhausted solution surrounding the electrode is readily renewed by mere difference of specific gravity producing a flow. But, with large parallel plate electrodes, this rapid renewal of dense solution becomes impossible, and the electrode is soon surrounded with a weak solution. This state of things must be recognized in adjusting our battery arrangements. Electrotypists not aware of this fact find themselves much perplexed by failing

to accomplish with large plates what is so easily done with medals or small plates.

It would, at first sight, appear that, by strengthening the solution of sulphate of copper, a more rapid supply of metal to the electrode would be obtained. Unfortunately, the effect of this is to diminish the solvent capacity of the water in the solution for the sulphate formed on the positive electrode by the action of the transferred acid. The grand essential in electrolysis is liquidity. Thus, if the quantity of free water surrounding the positive electrode be small, this electrode is soon enveloped in a saturated solution, and the newly-formed salt remains undissolved upon it. This salt, being a non-conductor, virtually excludes the electrode from the solution, and thus arrests the current, except when the efflux of saturated solution permits the salt to dissolve, and so reopens the passage for the current in irregular quantities. From this spasmodic action result plates of copper-sand, or sometimes copper as soft as lead.

By applying heat to the solution when this state of things exists, the solvent capacity of the water for the salt is increased, rapid diffusion takes place, the salt is carried to the negative electrode, and the exhausted water to the positive electrode; the dormant batteries rush into uninterrupted action, and in a short time a plate is deposited, having all the hardness and elasticity of hammered or rolled copper. Smee's conditions, then, seem to maintain themselves. The electrotypist's axiom of "work slowly," requires to be reversed into "the quicker the work, the better the quality."

Laboratory apparatus.—Figure 1 is a plan of the coast survey electrotype laboratory. The glazed partition, *b*, *b*, *b*, *b*, with a door, *d*, separates the battery room from the general laboratory, and permits an easy inspection of the batteries, without exposure to their fumes. The laboratory floor is about six feet above the ground, and slopes inward from the sides towards the scuttle holes, *h*, *h*, *h*, *h*, arranged for discharging the waste liquids spilled upon the floor. To obviate the deleterious effects of working on a floor saturated with chemical agents, when any solutions are spilled, the floor is well flooded and brushed, the water passing off through the scuttle holes. There are four battery cells, placed as indicated, B, B, B, B. A rectangular India-rubber bag, supported by a deep wooden box, contains the battery solutions. Each cell can contain nine silver and eight zinc plates. A metallic connection unites all the zinc plates of a cell, and another one all the silver plates. Each cell can be used as an independent battery, or two, three, or four cells can be connected in consecutive or simultaneous order, or all combined into two pairs of two in consecutive or simultaneous order, or into one group of three and one of one. The position of the vertical decompos-

ing vat is shown at V, and that of the horizontal vat at H. S is a large tub for washing plates. The tub C contains the solution of chlorid of iron. Q is the quicksilver tub, and W, W, are fresh water tubs. F is the furnace, and *d*, *d*, *c*, *c*, are heating tubes connecting with the vat H. T is a flat iron table.

Fig. 2 exhibits a cell and its included plates, with their mode of suspension.

Fig. 3 represents the suspending frame of wood and the attached plate, P, prepared for immersion in the vertical vat.

Fig. 4 shows the vertical vat and the plates suspended in it.

Fig. 5 represents the adjustable plate-supporting frame used in the horizontal vat.

Fig. 6 exhibits the interior arrangement of the horizontal vat, a blank plate and an engraved original being in position; also the connecting copper rods leading to the battery.

Fig. 7 represents the heating furnace. The door for admitting air is shown at *a*, and is so connected with an adjusting compound bar of iron and zinc that by an adjusting screw it can be arranged to regulate the draught, opening or closing the door, thus maintaining a uniform heat in the solution. After getting the fire started, this door is set so as to close when the solution reaches a heat of 180°. In principle this furnace is similar to a bath-heater. A tubular helix of lead is coiled within it like the worm of a still, and the terminating branches *c* and *d* lead to the horizontal vat, the branch *c* uniting the top of the vat just below the liquid surface with the top of the coil, and *d* at the bottom of the vat with the bottom of the coil. Hence follows a circulation of the solution from the furnace at top and into it at bottom.

Manipulation.—When a plate is to be electrotyped, it is placed on trestles above the open scuttle holes, *h*, *h*, *h*, *h*, and thoroughly cleaned by washing with alkalies and acids. It is then silvered, iodized, and placed before a window. A plate of rolled copper an inch larger than the engraved plate is then selected, placed on the flat iron table, and beaten with mallets until a steel straight edge shows it to be plane. It is then weighed and fixed in the vertical plate frame by two copper hooks. The engraved plate is then similarly fixed in a similar frame, when both are placed in a vertical vat and connected with the battery.

The process does not go on well when the plates are vertical, but it is necessary to start the castings in this position to prevent dust, motes, or specks of impurities, from settling on the face. As the rolled plate dissolves, its impurities rapidly render the solution muddy, and endanger the face of the forming plate. For common electrotypes dust or mote specks are not detrimental; but the coast survey copper plates being not inferior in fineness of lines to fine steel plates, the effect of impurities settling on the face of their copies is to give the impressions a clouded appear-

ance. On first immersing the plate, the solution should, therefore be perfectly clean. Formerly, after each use of the vertical vat, it was emptied and washed out. When the solution had deposited its sediment it was drawn off and strained through very fine cotton. This whole operation was extremely disagreeable, and consumed a whole day of one man.

By a simple expedient I have saved the necessity of cleaning the vat oftener than once a month. To guard the new plate from specks and impurities, a bag of fine cotton is drawn over a slight wooden frame, which keeps it distended. An hour or more before the solution is wanted, the bag, with its included frame, is placed on top of the solution and loaded with the copper bars used to support the plate frames. The weight causes the bag to sink gradually, filtering the contained solution as it goes down; the impurities cannot wholly choke the meshes of the cloth, as a fresh portion is constantly brought into action during the sinking. I thus filter the solution without taking it from the vat or disturbing the sediment, saving much labor, time, and annoyance.

The plate remains in the vertical vat over night, and preparations are made in the morning to transfer it to the horizontal vat. The furnace is first brought into action. A new plate of blank copper, an inch larger than the matrix, is flattened on the iron table, and bolted to the edges of wooden bars by platinum bolts, for the purpose of preventing the plate from sagging downwards when supported horizontally. The plate so arranged is called the strapped plate. The coated matrix is then taken from the vertical vat, disengaged from its frame, and arranged in the horizontal frame. A wooden wall, an inch high, then surrounds the plate, and on this wall the strapped plate is laid, when the whole combination is placed in the horizontal vat and the connection with the battery established. The positive plate is then taken from the vertical vat and its loss of weight noted and recorded. From the known superficial area of the matrix, the quantity of copper required for a casting one-eighth of an inch thick is computed and recorded. The blank copper consumed in both vats must equal this amount before the required thickness is reached, allowance being made for impurities of rolled copper and roughness on the back of the electrotype. After a few hours of action the strapped plate becomes so loaded with impurities that they will begin to drop on the electrotype; this plate must, therefore, be removed from the vat and a new one immediately supplied. The dirty plate is then washed in the large water tub, and when cleaned its loss of weight is found and recorded. By the amount of loss the action of the batteries is tested, and it is found, if Smee's laws are being observed. Vigilance must now be exercised in watching the batteries and rate of work, and the power must be varied to suit circumstances.

The entire working battery generally requires renewal once a day, the process being conducted as follows: One zinc and one silver plate are taken from the battery; the silver placed in the solution of chlorid of iron, and the zinc taken to the water tub outside the door of the battery room, where it is scrubbed clean with a hard brush. It is then re-amalgamated at the quicksilver tub, and taken back to the battery. The silver plate is transferred from the chlorid of iron solution to the adjacent fresh water tub. Another plate is then transferred from the battery to the chlorid solution, and another zinc cleaned, washed, and put back in the battery with the first silver. In this manner the whole battery can be renewed without sensibly interrupting its action.

When the loss of weight from the rolled copper in both vats indicates that the required thickness of the electrotype is gained, the plate is withdrawn from the battery, detached from its frame, its back smoothed, and its edges filed, until a separation can be made. By separation, the original becomes liberated, and the alto or reversed relief is silvered and electrotyped exactly as an original. The copy from it, or the electrotyped basso, will, if the process has been properly conducted, be a perfect fac-simile of the original, and in hardness, ductility, and elasticity, will equal the best rolled and hammered or planished copper plate.

ART. XXXIII.—*Brief Characters of some New Genera and Species of Nyctaginaceæ, principally collected in Texas and New Mexico*, by CHARLES WRIGHT, Esq., under the direction of Col. J. D. GRAHAM, U. S. Topogr. Engineers, late Chief of the Scientific Corps of the Mexican Boundary Commission; by ASA GRAY, M.D.

(Concluded from p. 263.)

ABRONIA, Juss.

ABRONIA (TRIPTEROCALYX) CYCLOPTERA.—Abronia (Tripterocalyx) micranthum, *Torr. in Frem. 1st Rep. p.* 96, *& in Emory, Rep. p.* 149. Cycloptera annua, & Apaloptera annua, *Nutt. in herb. Hook.*—The excellent specimens gathered by Mr. Wright on the Rio Grande, New Mexico, plainly show Dr. Torrey's A. micrantha was founded on the precociously fertilized state of a species, the fully developed flowers of which are the very largest of the genus. I will not hesitate, in this case, to change the specific name. In the appendix to *Stansbury's Exploration of the Valley of the Great Salt Lake*, p. 395, Dr. Torrey suggests that the plant in question may be only a small-flowered state of Abronia mellifera. The Abronia mellifera of Douglass, however, is a manifestly different species, the fruit of which is winged, indeed, and more strongly than in any other genuine Abronia,—so

much so as to forbid the separation of Tripterocalyx as any thing more than a subgenus,—but the wings are triangular, pointed, and entirely lateral, not meeting over the summit of the fruit. Its flowers too are greenish, while those of A. cycloptera are light purple. Furthermore, what Dr. Torrey takes for the Abronia mellifera is the A. fragrans, *Nutt. in herb. Hook.*, which is distinguished, probably specifically, by its very large and broad, scarious or petaloid leaves of the involucre, and its white, or "porcelain-colored" flowers. The *monocotyledonous embryo*, first noticed by Dr. Torrey in his A. micrantha, he has since shown to exist throughout the genus; the inner cotyledon being constantly wanting. Dr. Torrey's observation appears to have escaped Prof. Choisy's notice. In Emory's Report, Dr. Torrey has further corrected the character of the genus, especially noticing the adhesion of the filaments to the tube of the perigonium, and the two-cleft lobes of the limb of the latter, which are not "deciduous," but involute after anthesis.

QUAMOCLIDION, Chois.

1. Quamoclidion oxybaphoides (sp. nov.): caulibus procumbenti-diffusis gracilibus; foliis omnibus profunde cordatis longiuscule petiolatis, infimis reniformibus, superioribus acuminatis nunc subangulatis; involucro trifloro profunde 5-fido cum pedunculis laxe paniculatis glanduloso-viscosissimo, lobis ovatis acutiusculis perigonio campanulato paullo brevioribus; staminibus 3; fructu subgloboso-obovoideo.—At the foot of mountains east of El Paso, in the shade of high rocks (*Wright*, No. 596): also in mountain ravines of the Chiricahui Mountains, at Guadalupe Pass (*Wright*, No. 1721 in part); Sept., Oct. In habit and foliage this plant resembles Choisy's Quamoclidion nyctagineum, except that it is more slender, and smaller in all its parts, and the leaves (from one to two inches in length and breadth) all have a reniform-cordate base. The involucre is very similar, except that the lobes are not acuminate, and scarcely acute; they are only 3 lines long; those of Q. nyctagineum, said by Choisy to be 3 lines in length, are twice that length in my original specimen. The few flowers seen of the present plant show a campanulate perigonium, barely four lines long, with no tube, except the globular base, and only three stamens. The fruit is smooth, destitute of ribs or angles, glabrous, blackish, and very obscurely rugulose-reticulated under a lens. Our plant is probably a congener of Choisy's Q.? angulatum (if what was represented as a multiple stigma in Moçino and Sesse's drawing be no more than the coarsely granulated simple stigma of this and other species), and perhaps closely related to it; but the stamens are only three, and apparently not "long exserted." Their number and the form and size of the perigonium would refer the species to Oxyba-

phus; but I rely rather on the strongly five-ribbed fruit, with the at length dilated and scarious involucre, to distinguish that genus. Quamoclidion, strengthened by this and the following species, it seems most convenient to retain as a genus, although it differs from Mirabilis only as the first section of Oxybaphus differs from the second. While the form of the perigonium of the present species is as in Oxybaphus, that of the following resembles that of Mirabilis.

2. Quamoclidion multiflorum (Torr. ined.): caulibus suberectis; foliis breviuscule petiolatis subcordatis acutis; involucro magno glabro campanulato 5-fido 4–8-floro; perigonio infundibuliformi, limbo expanso; staminibus 4–5. Oxybaphus multiflorus, *Torr. in Ann. Lyc. N. Y.*, 2, *p.* 237. Nyctaginia? Torreyana, *Chois. in DC. Prodr.* 13, *p.* 430. Stony hills near the copper mines of Santa Rita, New Mexico (*Wright*, No. 1703). To this belongs No. 1327 of Coulter's Mexican collection; No. 559 of his Californian collection; No. 85 of the collection of Wislizenus, &c. The involucre is an inch in length; and the full-grown perigonium fully two inches long. In the original description, Dr. Torrey plainly stated that the involucre is "quinquefid," and therefore gamophyllous.

BOERHAVIA, Linn.

§ 1. Fructus 5-angulatus vel 5-costatus, obpyramidatus vel obovatus.

1. Boerhavia purpurascens (sp. nov.): caulibus e radice annua adscendentibus laxe ramosis; ramis glanduloso-viscosissimis; foliis caulinis ovalibus oblongisve utrinque obtusis subtus pallidioribus sæpeque purpureo tinctis glabris, ramealibus lanceolatis linearibusve parvis glandulosis; pedunculis paniculatis glomerulum capituliformem 5–8-florum gerentibus; bracteolis 3 oblongis hirsuto-viscososissimis cuspidatis perigonium campanulatum fructumque adæquantibus; staminibus 3; fructu brevissime pedicellato obovato utrinque obtuso lævi, costis angustis validis.—Stony hills near the copper mines of Santa Rita, New Mexico, Aug. (*Wright*, No. 1725). Plant a span to a foot high. Leaves 6 to 18 lines long, very unequal. Rhachis of the glomerule not elongated with age, only two lines long after the fruit has fallen; the persistent pedicels therefore approximate, less than a line in length, the apex more cup-shaped than usual. Bracts tinged with purple, very viscous, enveloping the fruit, at length deciduous; of these the broader one is the true bract, although borne on the pedicel above its middle; the two lateral are the proper bractlets. Perigonium purple, a line and a half long, without any constricted tube. Fruit a line and a half long, perfectly smooth and glabrous, not at all corrugated, with 5 rather distant

and narrow salient ribs.—The following appears to be more nearly related to this than to any other; but it is probably a distinct species.

2. Boerhavia Wrightii (sp. nov.): caulibus e radice annua erectis gracilibus laxe ramosis ramisque glanduloso-viscosis; foliis oblongis undulatis nigro-punctatis subtus albidis, summis linearibus; pedunculis paniculatis spiculam brevem demum sparsifloram gerentibus; pedicellis brevissimis basi unibracteatis apice bibracteolatis; bracteis bracteolisque ovatis cuspidato-acuminatis ciliatis flore evoluto brevioribus; staminibus 3–4; fructu breviter obovato glabro inter costas 5 crassas ruguloso. Pebbly hills near El Paso, Sept. (*Wright*, No. 610). Near Messillas, Northern Mexico, *Gregg* (No. 533, scarcely in flower)? Plant about a foot high. Leaves thickish, small. Rhachis of the slender, interrupted, and mostly simple spikes an inch or more in length. Bract and bractlets purplish, deciduous. Perigonium smaller than in the preceding species, pale. Fruit barely a line in length.

3. Boerhavia linearifolia (sp. nov.): caulibus e radice lignescente diffusis paniculato-ramosissimis glanduloso-viscosis basi hispidis seu villosis; foliis linearibus et lanceolatis brevissime petiolatis mucronato-acutatis crassiusculis margine revolutis parce hispidis; floribus effuse cymosis breviter pedicellatis singulis basi 3–5-bracteolatis; bracteolis persistentibus; staminibus 5; fructu clavato-oblongo glabro utrinque obtusissimo, costis incrassatis.—Var. *β. glabrata:* caulibus inferne foliisque glabris vel glabratis.—Western Texas, common, *Wright*, (No. 608, 1724,) *Lindheimer*. Saltillo, Mexico, *Gregg*. Plant diffusely many-stemmed, forming large bunches. Perigonium purple; the limb rotate when fully expanded, and half an inch in diameter: constricted tube scarcely any. Fruit a line and a half long.

§ 2. Fructus 10-costatus, turbinatus. Perigonium hypocrateriformorphum, tubo subelongato villosissimo. Flores glomerulati ad nodos ramorum paniculæ.

4. Boerhavia eriosolena (sp. nov.): glabra; caule erecto hinc inde glutinoso superne ramisque floridis nudis; foliis carnosis ovatis nunc subcordatis margine denticulato-glandulosis junioribus subtus petiolisque parce hirtellis, superioribus in bracteas subulatas parvas transeuntibus; pedicellis brevibus seu brevissimis; bracteolis 4–5 scariosis oblongis cuspidato-acuminatis sub flore verticillatis involucellum efficientibus persistentibus fructu turbinato crasse 10-costato glabro apice truncato paullo brevioribus; perigonio limbo roseo; staminibus 5.—Valley near Azufrora, in Cohahuila or Durango, Northern Mexico, *Dr. Gregg* (No. 512). Plant 3 feet high; the root not seen; the stem rather stout, angled above. Pedicels one or two lines long, three or four together

at each node of the elongated branches of the cymosely paniculate, ample inflorescence, forming a fascicle, which at length is frequently evolute into a proliferous branch. Tube of the perigonium a line and a half long above the abruptly enlarged fructiferous portion, very villous with long and spreading or implexed hairs; the limb 4 or 5 lines wide when fully expanded. Fruit (immature) two lines long.

§ 3. Fructus leviter 10-costatus, elongato-clavatus, rectus, superne sæpius muricato-glandulosus. Perigonium (majusculum) cyathiforme vel infundibuliforme. Flores umbellati.

5. Boerhavia Grahami (sp. nov.): glabra; caule gracili e radice perenni erecto; foliis cordatis repandis, summis ovatis mucronatis; pedunculis paniculatis seu primariis alaribus solitariis folia multum superantibus; umbella 7–12-flora; perigonii limbo cyathiformi viridi-flavo, tubo (supra basim fructiferam) brevissimo; staminibus 2; fructu lineari-clavato viscoso-puberulo superne parce muricato-glanduloso pedicello æquilongo demum geniculato-deflexo. Rocky hills of the Sonoita, Sonora, *Wright* (No. 1715). Bracts 5 or 6, minute, forming an inconspicuous involucre, deciduous. Pedicels 4 to 6 lines long. Perigonium at most two lines long above the fructiferous base. Stigma peltate, as in the genus generally.—Perhaps too closely related to B. scandens; but the stem appears to be truly upright, and the constricted tube of the perigonium is extremely short. The species is dedicated to Col. J. D. Graham, under whose auspices the specimens were collected. Some of the flowers fructify precociously, as in so many Nyctaginaceæ.

§ 3. (Senkenbergia) Fructus leviter 10-costatus, elongato-clavatus, curvatus, hinc gibbosus, demum geniculato-deflexus. Perigonium infundibuliforme (majusculum). Flores racemosi, unibracteati, ebracteolati. (Tinantia, *Mart. & Gal.*, non *Schweidweiler*. Lindenia, *Mart. & Gal.* olim, non *Hook.* Senkenbergia, *Schauer.*)

6. Boerhavia gibbosa, *Pavon in herb.*—Lindenia gypsophiloides, *Mart. & Gal. in Bull. Acad. Brux.*, 10, *No.* 4, *p.* 17. Tinantia gypsophiloides, *Mart. & Gal.*, *l. c.* 11, *No.* 4, *p.* 30; *Chois. in DC. Prodr.* 13, *p.* 457. Senkenbergia annulata, *Schauer in Linnæa*, 19, p. 711.—Mexico, *Moçino & Sesse*, *Galeotti*, *Coulter* (No. 1434), *Gregg* (No. 515). On the San Felipe and San Pedro Rivers, W. Texas, *Wright* (No. 613, 1714). In the plant which flowered in the Cambridge Botanic Garden during the past summer, many of the blossoms were precociously fertilized in the bud, before it was full-grown; while others, even of the same raceme, expanded their rather handsome, rose-purple perigonium (the limb 4 lines in diameter). The pedicels are

barely a line long, much shorter than they are described by Choisy; while the ripe fruit, in well developed specimens, is 4 or 5 lines long (3 lines, *Choisy*): it is articulated with the apex of the pedicel (as it is in Boerhavia), glabrous, and destitute of glands, but sometimes sparsely verrucose with translucent pimples. As in most Nyctaginaceæ, when soaked in water, the surface becomes covered with a thick, mucilaginous mass, from the bursting of the epidermal cells and the uncoiling of the contained gelatinous threads. Prof. Choisy has remarked that the genus Tinantia is scarcely sufficiently distinguished from Boerhavia by its inflorescence and the singular form of the fruit. I adopt the later name of Senkenbergia for this subgenus, because there is an earlier genus *Tinantia* or *Tinnantia*. The first published specific name "gypsophiloides" is so inappropriate, that I venture, in restoring the plant to Boerhaavia, to adopt the characteristic name given by Pavon in his herbarium.

The other species distributed in Mr. Wright's numbered collections appear to be: B. ERECTA, *Linn.* various forms, all of them apparently with annual roots (No. 609, 1726, 1727, 1728); B. PANICULATA, *Rich.* (No. 611); and B. VISCOSA, *Lag.* (No. 612).

ART. XXXIV.—*On the Discovery of two species of Trichomanes in the State of Alabama, one of which is new;* by ASA GRAY, M.D.

WITH one exception, no Hymenophyllaceous Fern has been supposed to grow within the limits of the United States; nor, when the nature of our climate is considered, would any such Fern be expected to occur, except, perhaps, in Florida. The exceptional case referred to, that of *Hymenophyllum ciliatum* of Swartz, said by Willdenow to come from Pennsylvania, as well as the West Indies, doubtless rests on some mistake. At least, a search through the Willdenovian herbarium did not reveal the existence of any specimen to confirm this habitat; neither is the plant enumerated in the *Catalogus Plantarum Amer. Sept.* (ed. 2) of Muhlenberg, who was Willdenow's chief North American correspondent, nor is it found in the Muhlenbergian herbarium. The only person, so far as I know, who pretends to have seen the plant in this country is Pursh, who, in his *Flora Amer. Sept.*, p. 671, gives the habitat "In shady forests, on the trunks of old trees; Pennsylvania and Virginia, v. v." I fear that this statement cannot be implicitly received, however, since more than one case is known in which this author has extended the range of a species and employed the sign *v. v.* where he had never visited the assigned locality. No specimen of any Hymenophyl-

lum was to be found in the herbarium, chiefly of Virginian and Pennsylvanian plants, which Pursh formed for his patron, Professor Barton, nor in that which he communicated to the late Mr. Lambert, and used in the preparation of his Flora.

However the case may be in respect to that plant, it is no longer to be doubted that this elegant, and for the most part tropical or subtropical, tribe of Ferns has representatives in the United States; and I think it worth while to call immediate attention to so interesting and unexpected a discovery. This discovery was made by my excellent correspondent, Thomas M. Peters, Esq., of Moulton, Alabama, in the northeastern portion of that State. It was in July last that Mr. Peters found, about twenty-five miles south of Moulton, a species of *Trichomanes*, which he determined to be such. In December, the same gentleman, in connexion with J. F. Beaumont, Esq.,* found a second locality near Mountain Home, in the adjacent county of Lawrence (of which Moulton is the Shire town). Mr. Beaumont had sometime before discovered the plant in Franklin county, farther west, and had sent me specimens collected in November. Specimens liberally communicated to me by both these gentlemen so nearly agreed with *Trichomanes radicans* of Swartz,† especially with growing plants brought from Killarney, that I had little hesitation in referring them to that species; and this view was at once confirmed by the high authority of Sir William Hooker, to whom specimens were immediately forwarded. The fronds, however, are all smaller than the ordinary forms of Trichomanes radicans, being from two to barely five inches long; they are also narrower in outline, and less compound, being only bipinnatifid. The specimens from the two localities represent two forms of the species; one form having longer and narrower segments to the frond and long-exserted receptacles; the other is a more condensed form, with the receptacles less prolonged. According to Hooker the species is a very variable one, and most widely diffused, from Jamaica and the other West Indies to Mexico and Brazil, and even to the Sandwich Islands; while in the Old World it is found in Ireland, in the Azores, Madeira, Teneriffe, and even in Nepal.

The plant occurs, in Alabama, on the face of sandstone cliffs that overhang small streams, and particularly on the under surface of overhanging rocks of the kind, sheltered both from the sun and rain, but kept damp by percolation, or by the spray of adjacent cascades, at least for a great part of the year. I am greatly

* In a letter received since notice was sent to the printer, Mr. Beaumont states that he first met with the plant so long ago as December, 1850, in Franklin County, and has enclosed to me a fruiting specimen collected at that time.

† Taking that species, as now received by Hooker, to comprise the *T. brevisetum*, R. Br.; *T. scandens*, Hedw., &c.

indebted to Mr. Beaumont for live roots of the plant, which, though carefully planted in a *Ward case*, I have not yet succeeded in causing to vegetate.

On the 8th inst. (January, 1853), Mr. Peters was so fortunate as to detect, in the same region, a second species of Trichomanes, of a small size, with undivided fronds, growing in moss-like tufts. The specimens, which I have just received from the discoverer in a letter, have very little fruit, enough however to ascertain the genus, and to show that they belong to a new species, of Hooker's first section of true Trichomanes, and of his second subdivision, which contains T. muscoides, T. erosum, T. pusillum, and T. apodum. Our new Fern is more nearly related to the first of these (chiefly a West Indian species), having the involucre equally immersed in the body of the frond (which is not the case with the other species), and the receptacle very short. But the shape of the fronds, their slender stipes, and the total absence of an intramarginal vein are abundantly distinctive characters. In the shape of the broader fronds, and in the stellate hairs which sparsely beset their margins, our plant may be likened to T. reptans; but that species has a close and flabellate venation, and a cylindrical, exserted involucre, with a deeply two-lipped orifice.

I add the characters of the species, which may appropriately bear the name of its discoverer.

Trichomanes Petersii (sp. nov.): pusillum; caudicibus filiformibus tomentosis intricato-cæspitosis; frondibus (3–6 lineas longis) oblongo-lanceolatis ovato-oblongis vel minoribus late obovatis cuneatisve undulatis majoribus subpinnatifido-sinuatis obtusis glabberrimis (junioribus margine hinc indę pilis nigris 2–3-furcatis ciliatis) penninerviis in stipitem gracilem attenuatis; venis furcatis vel pinnato-ramosis liberis (intramarginali nullo); soro solitario terminali; indusio immerso tubuloso-infundibuliformi, ore dilatato libero leviter bilabiato; receptaculo (an semper?) incluso.—Hancock County, Alabama, not far from the Sipsey River; found only on the face of an isolated sandstone rock, within reach of the spray of a water-fall which is supplied for most of the season.—*T. M. Peters*, Esq.

The fronds, as in T. muscoides are very diverse in shape. The dilated-cuneate ones might be taken for the sterile form; but I observe that, more frequently than the narrower fronds, they bear a terminal indusium, which, however, is sterile and empty. There is a peculiarity about the venation; some of the branches of the primary veins being evanescent towards their base, so as apparently to lie free and independent in the frond. The slender stipe is as long as the frond itself.

ART. XXXV.—*On a method of exhibiting the Phenomena of Diffraction with the Compound Microscope;* by OGDEN N. ROOD, A.B.

[Read before the Berzelian Society of Yale College, March 8.]

WE proceed in the first place to describe a method by which any one possessing a compound microscope, may, almost without other apparatus, repeat in a highly satisfactory manner, all the ordinary experiments connected with the subject of diffraction: secondly we shall notice one or two of its bearings on microscopic vision.

For observing the phenomena of diffraction, an object lens, the half-inch for instance, is to be screwed to the lower end of the compound body, and the eye-piece is to be removed: if then the inside of the compound body is not well blackened, this must be attended to. A convenient way of obtaining a non-reflecting surface will be to coil a piece of black paper within the body. The instrument thus prepared is to be placed on a table, and a beam of sunlight thrown up through the objective by the mirror. A roll of blackened pasteboard eight or ten inches in length, and of such diameter that it will just fit around the compound body, will also be necessary. If now a piece of card or sheet-lead, having a circular aperture in the centre of about the $\frac{1}{150}$th or $\frac{1}{300}$th of an inch, be placed over the open end of the compound body, and the eye-piece be placed directly on the lead, and the aperture be viewed through the eye-piece, it will be seen surrounded by three or four beautiful, colored rings; the colors of the first reckoning from the centre will be yellow and dark red; the second, blue, yellow, orange, red; the third, blue, green, yellow, red; the fourth, faint green and faint red. If however the aperture be larger, ($\frac{1}{75}$th of an inch,) the eye-piece should be held at a distance of eight or ten inches from the aperture: for this purpose the roll of pasteboard is intended, the eye-piece being placed in one end of it, and the other fitting around the compound body; if then an aperture of $\frac{1}{150}$th of an inch in blackened card be viewed in this manner, the fringes will be seen, somewhat larger; there will be four sets, the colors being in the same order as above. An aperture of $\frac{1}{150}$th of an inch or thereabouts, may readily be made by placing a piece of sheet-lead on some hard substance, as a steel plate, and then pressing a fine needle into the lead. If the aperture be too large for being viewed in either way, the rings will be much broken. Next substitute for the aperture a slit in brass or tin-foil, the $\frac{1}{200}$th or $\frac{1}{300}$th of an inch in diameter. In the first case it should be viewed by the eye-piece at ten inches distance, in the second the

eye-piece may be placed directly on the slit: a white space will be seen running across the field bordered on either side by broad bands of yellow, red, blue, yellow, red, green, &c.; the colors following in the order given above. Four orders can in this way be observed; the phenomenon is exceedingly beautiful, the colors being very brilliant. By using a micrometer eye-piece, certain proportions which were observed by Fraunhofer to obtain among the bands, may be noticed. The experiment of the slits generally succeeds better than that of the circular apertures, though if the slits are not perfectly regular, the bands following in an inverse manner the irregularities, will be arranged in jagged lines. For observing the rings of color or of darkness formed *within* circular apertures or slits, gas light is preferable, though they may be shown by sunlight. A circular aperture, $\frac{1}{33}$th of an inch is placed over the open end of the compound body, and the eye-piece fixed in the pasteboard is held at about five inches distance. A white circular image of the aperture will be seen, and within it two small rings of blue and red. If the eye-piece be placed on the aperture, or on a larger one, rings of darkness will be observed. If the same plan be pursued with slits, *lines* of color or of darkness will of course be seen.

But if on the other hand, the edge of a piece of blackened card be introduced into the beam of divergent light, and the eye-piece placed upon it, it will be seen bordered by dark lines running parallel to its edges, and fine lines of light will project some distance into the shadow. When the eye-piece is removed ten inches the dark lines develop into colored fringes. If a piece of iron wire, $\frac{1}{100}$th of an inch in diameter, be placed as above, with the eye-piece at 11 inches, the centre of its shadow will be occupied by a line of light: if the wire is as fine as $\frac{1}{200}$th of an inch, the eye-piece may be placed directly on it. With a larger size, and the eye-piece properly placed, six or seven lines of light and darkness can be distinctly seen; and in general the external fringes will be distinct in proportion to the small size of the wire, while the internal lines are the reverse to a limited extent. If a circular opaque body, $\frac{1}{12}$th or $\frac{1}{25}$th of an inch be placed on a plate of thin glass, and viewed by the eye-piece at ten inches, besides the external fringes a circular white spot will be seen in the centre of the shadow, as though the body had been perforated. If fine chalk powder, &c., be sprinkled on the glass plate, and viewed by the eye-piece at ten inches, it presents an appearance of numerous fine dark lines, arranged in minute circles, their diameters being inversely as the size of the particles of dust.

For repeating some of M. Fraunhofer's experiments on gratings, an ordinary stage micrometer, having equi-distant lines ruled at $\frac{1}{800}$th or $\frac{1}{500}$th of an inch apart, may be used. This when placed as above, shows a white space in the middle, with a cer-

tain number of prismatic spectra on either side, the purity of the colors being dependent on the regularity with which the lines are ruled. With lines $\frac{1}{4}\frac{1}{0}$th of an inch apart, five spectra on either side were observed. If however the cornea of a fly be taken as a grating, and viewed at 11 inches, a central white spot is seen, surrounded on all sides with great numbers of prismatic spectra. The appearance is one of great beauty.

Having thus described an easy method of performing experiments on diffraction, we proceed to notice one or two of its bearings on microscopic vision. And we would state in the outset, that all the experiments alluded to above may be performed by the microscope when arranged as it ordinarily is for observation; that is, let an inch or a half inch objective be screwed on, the eye-piece being in its proper position; let parallel rays of the sun be thrown up through the body by the plane mirror, and let an aperture $\frac{1}{1}\frac{1}{5}\frac{1}{0}$th or $\frac{1}{2}\frac{1}{5}\frac{1}{0}$th of an inch be placed on the stage and viewed as an ordinary object. As long as the aperture is in focus, nothing remarkable will be observed, but if the compound body is carried within or without the focus, the aperture will be seen to dilate and to become surrounded with colored rings precisely as above. Reckoning from the centre, the rings will be yellow, dark red, blue, yellow, red, blue, &c. If a fine slit be used instead, the same sets of colored bands are seen as described above; in either case, as the object lens approaches the focal point the rings or bands contract and disappear. By turning the light a little obliquely, so as to make it faint, or by using a larger aperture with rather faint sunlight, dark rings or lines can be observed in the centre of the white spot. If the edge of an opaque body be brought into the field of sunlight, and if it is a little out of the focus, it will be seen bordered with the same dark or colored lines as described above. To observe the internal fringes let a piece of fine wire, ($\frac{1}{2}\frac{1}{0}$th of an inch,) be placed on the stage, and viewed a little out of the focus, it will be seen filled up internally by lines of light and darkness; three or four external fringes in the shape of distinct black lines will also be seen on either side. If a very fine scratch on glass be viewed in this manner, the external fringes will be well developed; reckoning from the centre, they will be, blue, yellow, red, blue, &c., this being the case when direct parallel rays of the sun are used, the phenomena being different with oblique light.

We have now seen that when the direct rays of the sun, or a lamp are used, we must expect to find the appearance of microscopic objects modified by diffraction; for, using high powers with the best fine adjustment, all parts of the object cannot generally be in the focus at the same time: consequently it will be observed that when under a power of even 200 diameters, the object being most accurately focused, it exhibits marked phenomena

of diffraction. Let us now take one of the simplest cases of bodies viewed by oblique light, viz. a single fibre of black silk, a single strand of a spider's web, or a fine scratch in glass; let it be viewed under a power of 400 diameters, the light being that of the sun, thrown obliquely across the object most accurately focused. The object will be seen to dilate, and three bands of color, blue, red and yellow, will represent it; the colors all broad and distinct. Within the bands and running parallel with them, are great numbers of fine dark lines, placed very near to each other, and with considerable regularity, and in fact closely resembling the lines on certain test objects; moreover, it would seem that the better the object lens, the more distinct the lines become. That these black lines are only fringes of diffraction may be readily shown, for by moving the compound body a little out of focus, they develop into the ordinary colored fringes. If the line be a strand from the spider's web, the fine black lines are very abundant, and extend on one side a considerable distance beyond the colored space. If a fine scratch on glass be viewed in this manner, under 400 diameters, the light can be so arranged that it shall exhibit the same phenomena; in general, if the line has any breadth, and if it be rotated so that the light is thrown along its length, a position will ordinarily be found when the external fringes for the most part disappear, while the internal ones, if there are any, become more distinct. The foregoing may perhaps throw some light on the fact that so many persons see longitudinal lines on test objects, (Naviculæ,) while they fail to show the transverse; but nevertheless, in using very oblique sunlight not only is a single line always accompanied by many parallel fringes of diffraction, but after these have been made to disappear by revolving the line, often a distinct set of *transverse* lines at right angles to the former take their place. It would seem from these facts that perhaps central light is as safe in testing objectives as any other.

In viewing fine gratings *under* the microscope, that species of illumination called background should be employed, and instead of an artificial grating which could not readily be procured sufficiently fine and regular, use scales of the Lepisma saccharina, or of the Lycena argus, both of which have parallel markings. It will be noticed that when the light is thus thrown along the lines, the scale is generally of a dull blue; on revolving it slightly it changes from blue to bright red, to orange, to yellow: at the next stage it is very bright and slightly tinged with blue: turning it farther, it changes from yellow to red, to the original dark blue. When it has reached its maximum of brightness, if the compound body be carried out of the focus, one or more beautiful prismatic spectra will be developed by the lines on the scale, consisting of red, orange, yellow, green and blue. Some scales of the Lepisma, with the one inch objective, show two

similar spectra side by side, others three; others again, one principal spectrum near the spot where the image of the scale vanished, and another faint spectrum which advances or recedes from the principal one, as the compound body is moved up and down. The distinctness of the colors in these spectra, depending as they do on the regularity with which the lines are drawn, furnish a means of forming a judgment on this point. The spectra are of course formed at right angles to the direction of the lines. By means of these spectra the existence of lines on certain scales was detected, when the power employed, (40 diameters) was wholly unable to exhibit them; in fact, to show the lines distinctly, a power of 300 diameters with oblique light was found necessary.

The phenomena of diffraction also afford a ready explanation of the small concentric circles which are so often seen covering slides containing microscopic objects: they are of course owing to exceedingly fine particles of dust which produce dark rings, the size of which is inversely as that of the particles of dust. Of the same nature are the minute rings seen when looking through the microscope without any object on the stage; in this case the dust will be found on either lens of the eye-piece.

Speaking of small particles of dust, &c., it may not perhaps be amiss to mention a method of obtaining a measure of small points or of very fine lines, which method has however nothing to do with diffraction. The eye-piece micrometer is used; after making the proper determinations to ascertain the value of the spaces between the ruled lines, the graduated slip of glass is removed from the eye-piece, placed on the stage, and the proportion which the thickness of a single line on the graduated glass bears to the distance between two lines, ascertained for one line by the proper measurements. In one case this was found to be $\frac{1}{60}$th; that is, the space between two lines was 60 times the thickness of a particular line. Let now the slip of glass be replaced in the eye-piece, and suppose that with a power of 400 diameters, the space between two lines corresponds to $\frac{1}{2000}$th of an inch; it is evident that the breadth of the particular line determined is now $= \frac{1}{60}$th of $\frac{1}{2000}$th; that is, equal to $\frac{1}{120000}$th of an inch. This of course can be directly compared with lines, dots, &c. on test objects. In the case above mentioned, the line determined was quite coarse—could readily be seen by the naked eye; by using a fine line in the micrometer eye-piece, it is evident that this method admits of being carried much farther.

In conclusion, we would remark that this subject seems worthy of an extended investigation, not only on account of the modifying influence diffraction exerts on the appearance of microscopic objects, but also because it is probable that by a skillful use of phenomena of diffraction, we should be able to detect, indirectly, the existence of certain kinds of structure, when the best objectives had wholly failed to demonstrate it.

Art. XXXVI.—*On Minerals accompanying Chromic Iron;* by Thomas H. Garrett.

In a former essay in this Journal, (vol. xiv, p. 45,) I embraced only chromic iron, and in the present I propose to introduce several of the minerals accompanying it.

Kämmererite.—This beautiful mineral occurs in considerable quantity in chromic iron and its associated serpentine at Wood's Pit, and at the mine on the line between Pennsylvania and Maryland, a few miles from Texas, Lancaster Co., Pa. It forms vein-like projections in the ore and serpentine, or lines seams between the ore and its enclosing talcose minerals.

Its structure is micaceous or foliated, fibrous, and graduates from these into a massive variety. The foliated passes into talc, the fibrous into hornblende, and the massive into serpentine. The more compact portions present the characters of Rhodochrome, and since Hermann's analyses of the two minerals from L. Iktul indicate similarity, I conclude that Rhodochrome is an impure form of Kämmererite. That it is a distinct chemical compound is shown by its crystalline form, which I have observed in several specimens, and which is described by Hartwall as a hexagonal prism. The form is right rhombic, presenting hexagonal tablets with bevelled edges. The combinations are the vertical rhombic prism with the large main end plain and small lateral end planes, (forming a hexagon,) a lateral rhombic prism on the edges of the end planes, and the octahedron replacing the edges of the vertical rhombic prism.

The following are the results of my analysis of a pure specimen, between fibrous and foliated, and selected with care.

Silica, ...	37·657
Oxyd of chrome, . . .	3·604
Alumina, ...	11·823
Magnesia, ...	24·974
Lime, ...	4·113
Protoxyd of iron, . . .	2·499
Protoxyd of nickel, . .	0·672
Water, ...	13·582
	98·924

The simplest formula according to the analysis would be $2(R_2O_3, 3SiO_3)+11(RO, HO)$. And here I may be allowed to draw attention to a remarkable feature among some of the numerous talcose minerals; that in a large proportion of them the number of equivalents of water and of RO bases is equal. Hartwall's formula for Kämmererite is $2(RO\,SiO_3)+R_2O_3, SiO_3+6HO$, although $5\frac{1}{2}HO$ satisfies the analysis more exactly. Dr.

Genth has recently analyzed the same mineral from Lancaster Co., and given it the name of Rhodophyllite, with the formula $3(RO\,SiO_3)+2(R_2O_3, SiO_3)+9(MgO\,HO)$ which agrees well with his analysis. Hermann's recent analysis of the same mineral from the Ural is unquestionably erroneous.

I do not therefore consider the true formula of Kämmererite as absolutely determined, and since these hydrotalcose minerals insensibly pass into each other, Dana has undoubtedly acted judiciously in placing Kämmererite under the previously determined Pyrosclerite, especially as they are both trimetric.

Bronzite.—This mineral is repeatedly seen in the serpentine near Texas, half a mile west of the village, constituting large masses, which are highly crystalline, foliated and fibrous. A selected specimen from this locality yielded:

Silica, ...	55·451
Alumina, ...	1·127
Magnesia, ...	31·832
Protoxyd of iron, . . .	9·603
Protoxyd of manganese, . .	0·984
	98·997

Although parts of the same mass were penetrated by chromic iron, yet neither chrome nor nickel have influenced the Bronzite. Its formula is $RO, Al_2O_3+14(3RO, 2SiO_3)$, the first member is evidently an impurity, and the last which is the true formula of the mineral, is that of Augite, and not that of Anthophyllite, as it has been generally called. It will be observed to agree closely with the Bronzite from Ultenthal, analyzed by Regnault (Dana's Min. 3d ed., p. 269), but the mineral from Texas is not characterized by the usual metalloidal lustre of Bronzite.

Emerald Nickel.—This mineral with its brilliant green color, contrasts strongly with the lustrous black of the chromic iron in which it occurs, and with the purple or lilac hue of Kämmererite. It either forms so thin a coating upon the chromic iron or talcose minerals, or is so intimately and uniformly blended with the latter, that I have not been able to obtain a specimen sufficiently pure to determine its exact composition. The following analysis was made of small fragments selected with great care:

Silica, ...	36·823
Alumina and oxyd of iron, .	1·396
Magnesia, ...	16·579
Lime, ...	3·839
Oxyd of nickel, . . .	30·837
Carbonic acid, . . .	4·363
Water, ...	8·551
	102·388

The oxyd of nickel may be in slight excess. The proportion of equivalents is,

SiO	MgO	CaO	NiO	CO_2	HO
8	8	1½	8	4	9½

If we may theorize upon such a complex composition, I would suggest as the most likely grouping of the mixture:

$4(2NiO, CO_2, HO)$ Emerald nickel (pure).
$6(MgO, SiO_3, HO)$ Meerschaum.
$3MgO, 2SiO_3$ Augite.

I have not found a single specimen, which upon treating with acid, will not show a white talcose residuum, which appears to be Meerschaum, and not Marmolite as I had at first supposed.

Dolomite.—It is found in crystalline masses with mamillary surfaces lining cavities and fissures in the serpentine rock near Texas, and that surrounding the chromic iron at Wood's Mine. It yielded:

Carbonate of lime, . . .	51·90
Carbonate of magnesia, . .	46·86
Carbonate of iron, . . .	1·24
	100·00

The proportion indicated by the analysis is almost exactly $CaO, CO_2 + MgO, CO_2$. Although magnesia is in very great excess, and lime in minute proportion in the adjoining rocks, and even large deposits of hydrocarbonate of magnesia occur, it is interesting to find the percolating waters forced by the stronger affinities of lime to share its solvent power between magnesia and lime in equivalent proportions.

ART. XXXVII.—*On the Causes which may have produced Changes in the Earth's Superficial Temperature;* by W. HOPKINS, Esq., M.A., F.R.S., Pres. G.S., and Pres. Cambridge Phil. Soc.

(Concluded from p. 259.)

3. *Discussion of the Relative Claims of the preceding Hypotheses.*

I HAVE already stated that I considered the hypotheses discussed in the first part of this memoir entirely insufficient to account for any sensible changes of terrestrial temperature in the later geological periods, as they obviously are to render account for a change from a lower to a higher temperature. In the earlier periods of the earth's history, supposing our globe to have been originally in a state of fusion, as there are many reasons for believing it to have been, its superficial temperature must have been greatly affected by its internal heat long after the solidification of

its surface had commenced. Undoubtedly this cause may be appealed to as sufficient for the production of almost any amount of terrestrial temperature; but, if the temperatures thus to be accounted for be many degrees above the existing temperatures, we can account for them by this theory only with reference to periods of very remote geological antiquity. I have also shown that any sensible effects of a difference of intensity in stellar radiation can be referred only to similarly remote epochs, and even for those periods the theory founded upon this notion appears to me vague and unsatisfactory.

Another theory of the changes of terrestrial temperature has been founded on the notion of a variation in the intensity of solar radiation. This cause, once admitted, might undoubtedly be deemed adequate to account for all the changes in question, nor does there appear to be any well-defined *à-priori* objection to it. No theory, however, can be satisfactory which presents itself as a mere hypothesis framed to account for a single and limited class of facts, and unsupported by the testimony of any other class of allied, but independent phenomena. The reception of such a theory must always be accompanied with great reserve, and must depend less on its own positive claims, than on an equal or greater want of such claims on the part of rival theories.

The theory which attributes the changes of terrestrial temperature to a varying configuration of land and sea is scarcely less indefinite than the others in its direct application to account for the difference of temperature between the present and the very remote geological epochs, on account of our ignorance of the disposition of sea and land in any but the most recent geological times. In the more remote periods, more than one of the causes here specified may have had their influence; but in accounting for the more recent changes of temperature, the last mentioned theory appears to me to have by far the greatest claim to our attention. I have endeavored in the preceding sections of this second part of my memoir to trace the consequences of certain hypothetical configurations of the earth's surface, and to explain the conditions under which a degree of cold might exist adequate to produce the phenomena of the Glacial Epoch. I propose in this concluding section to offer a few leading observations on the relative claims of these different hypotheses to our acceptance.

30. The most obvious mode of producing a great degree of cold is by local elevation. If we attribute the former presumed cold of western Europe to this cause alone, it would be necessary as I have shown (§ 24, p. 253), to elevate the whole region into a vast mountain-range, attaining in some parts the height of 10,000 feet or upwards. But all geological experience assures us that no such mountain-range exists without numerous dislocations and other phenomena of elevation having determinate relations to the

elevated tract. Of such characteristic phenomena not the slightest traces have been recognized. If it be urged that the elevation might be more local than here supposed, I would reply that such an hypothesis would rather strengthen than weaken the objection: for the more local the elevation, the more certainly, I think, would it be accompanied with dislocations which could not escape detection. I should reject without hesitation any theory founded on the hypothesis of an elevation during the glacial period, at all approximating to that which would be necessary to produce the required degree of cold.

31. Again, a great degree of cold might be produced by the conversion of a sufficient portion of the Atlantic into dry land. But this would also require an elevation of western Europe, probably of several thousand feet (§ 25, p. 254). Now if the cold of the glacial epoch were thus produced, this enormous area of the Atlantic must have been uplifted from its former level immediately previous to that epoch, and must since have again subsided. Considering the probable depth of the Atlantic Ocean, this movement must indeed have been enormous, and yet, although occurring at the most recent geological period, not a trace of it is observable either on the European or American side of the Atlantic. Under any circumstances, a theory founded on such an hypothesis, would, I think, be most unsatisfactory, and cannot be accepted in opposition to any other theory which may be free from objections of so grave a character.

We may also observe, that any theory of the production of cold solely by the *elevation* of the regions presenting glacial phenomena would be insufficient to account for many of these phenomena. It would be necessary that such a theory should embrace also the *depression* of such regions beneath the level of the sea, either before or after their elevation, for some of the phenomena in question may be referred to floating ice and currents of water with quite as much certainty as others can be to the action of glaciers.

32. Again, I have shown that the requisite degree of cold for the production of glaciers might arise from the diversion of the Gulf-stream into some other channel, the submergence of a great portion of the existing European continent, and a cold current from the north. This diversion of the Gulf-stream might be produced by the elevation of a portion of the bed of the Atlantic so as to form connecting land between the most western part of Africa and the most eastern portion of South America. But this would require an enormous movement, of which, I believe, not the slightest geological indication has been recognized, and the hypothesis is therefore liable to the same objection as that which may be made against the supposition of the more northern portion of the Atlantic having been elevated into dry land during

the glacial period. But there is another mode in which the diversion of this great current may, as it appears to me, have been effected, and to which I would especially direct the attention of geologists.

33. On the west of the continent of North America, a continuous and lofty range of mountains, the Rocky Mountains, extends from Mexico to the Arctic Sea. Another, but far less lofty chain, the Alleghanies, runs parallel to the eastern coast from near the Gulf of Mexico to the St. Lawrence. The great valley of the Mississippi and its tributaries, extending over some 30° of longitude, occupies the southern portion of the space between these two mountain-chains, being bounded on the south by the Gulf of Mexico, into which the Mississippi discharges its waters. In proceeding from the mouth to the source of this great river, we ascend about 1500 or 1600 feet.* Proceeding northward from its source, we descend into the great valley extending from the Gulf of St. Lawrence, on the eastern coast, along the great chain of North American lakes, to the mouth of the Mackenzie River, which discharges itself into the Arctic Sea. Thus a depression of 2000 feet would convert the valley of the Mississippi into a great arm of the sea, of which the present Gulf of Mexico would form the southern extremity, and which would communicate at its northern extremity with the waters occupying the submerged district above described as the great valley now occupied by the chain of lakes. A direct communication would thus be produced between the Gulf of Mexico and the Arctic Sea along the eastern base of the Rocky Mountains.

The Gulf-stream, flowing through the Straits of Bahama, and afterwards, in its northeastern direction, towards the North Sea and the coasts of Europe, is a current reflected from the shores of the Gulf of Mexico in consequence of the impossibility of its continuing the northwestern course by which it reaches the Gulf. But in the case now supposed, a direct opening would be made exactly in the direction which the current would continue to follow if uninterrupted. Its continuance to the Arctic Sea, and its non-reflection through the Straits of Bahama, would be the obvious consequences of the depression of the continent of North America. It would thus lose all sensible influence on the coasts of western Europe, but it would necessarily increase the temperature along its new course, and especially in the cold region of northwestern America towards the present shores of the Arctic Sea. The northeastern portion of the present continent would probably be much less affected by it.

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* See Sir John Richardson's paper "On some points of the Physical Geology of North America," Quart. Journ. Geol. Soc., 1851, vol. vii, p. 212.

34. It is probable that every great oceanic current must have its counter-current. Now, if the mass of water constituting the Gulf-stream were poured, as here supposed, directly into the Arctic Ocean, the only course, which any great counter-current from that ocean could follow, would seem to be through the North Sea intervening between the coasts of Norway and Greenland, and across the submerged portion of northern Europe. There would in fact be no other considerable opening from the north; for even if we suppose the low lands of northern Asia to be submerged, the mountain-ranges of that region would still offer an insuperable bar to any egress, except in the direction above indicated, for the waters of the Arctic Ocean. The opening through Behring's Straits would probably not be worthy of notice. These considerations appear to me to increase considerably the probability that this diverted course of the Gulf-stream would be attended by a cold current over the region now occupied by the continent of northern and western Europe.

35. The theory which I have here proposed respecting the diversion of the Gulf-stream, is not to be regarded as resting on an hypothesis framed simply to enable us to account for a particular class of phenomena. I regard it, on the contrary, as resting on a necessary inference from the submergence of the North American continent; for, I repeat, if that continent were submerged to the depth implied, as I believe by the most conclusive geological evidence, the course of the Gulf-stream could be no other than that which I have assigned to it. It is necessary, according to this view of the subject, to suppose this to have been the course of the current during the period of greatest cold in Europe, but it is by no means necessary to extend the supposition to the whole period of submergence of a great portion of the American continent. Many of the glacial phenomena of that region might be produced during its partial submergence, before the depression of the land was sufficient to admit the current to the Arctic Sea, or after its course had been again impeded, or altogether arrested, by the partial subsequent elevation of that continent. During the uninterrupted course of the current to the north, it would doubtlessly, as I have above remarked, increase, and probably very much increase, the temperature of the region corresponding to the present shores of the Arctic Sea; for nearly the whole of that mass of warm water, which now elevates so remarkably the temperature of the northern Atlantic up to the North Sea, would then proceed to discharge itself into the Arctic Sea between the Rocky Mountains and Hudson's Bay, by a course shorter, more direct, and probably therefore more rapid, than that by which it now reaches the coast of Iceland. I should consider it most probable that it would produce a temperature in the region along the northeastern flank of the Rocky Mountains, and extending

to the present northern shores of the American continent, higher than that of Iceland, and more nearly resembling that of some parts of our own island.

After having arrived at this conclusion, I was naturally anxious to learn whether any distinct indications had been observed of this climatal condition of the region in question, and recollecting to have heard my friend Prof. E. Forbes make incidental mention of the discovery in high northern latitudes of vegetable remains indicative of a temperature considerably higher than the existing temperature, I wrote to him, stating my own conclusions, to ascertain the precise locality in which these remains had been found, and the period to which they belonged. A few days ago I received his reply, stating that these plants might belong to the pleistocene period, and that the locality in which they had been found was precisely that above spoken of, along the flanks of the Rocky Mountains and between them and Hudson's Bay, as the region of which the temperature would probably be so much affected by the warm current from the Gulf of Mexico. I cannot but regard these remains as strongly confirmative of the view which I have now ventured to propound.

But how, it may be asked, could such a warm current be consistent with the glacial phenomena of the North American continent? I have already intimated the reply to this question. The exact period of these phenomena might be either anterior or posterior to that during which the Gulf-stream made its way to the Arctic Sea. Suppose the superficial configuration of that continent previous to its submergence to have been similar to its present configuration. A gradual subsidence might convert the northern portion of the continent into an arctic sea long before a free northwestern course would be opened for the Gulf-stream. With the exact similarity of the former and present configuration this extended arctic sea would be bounded towards the south by the higher land which now constitutes the watershed between the great northern valley of the chain of lakes and that of the Mississippi; but if the former and present configurations of the land were only approximately and not accurately similar, or if the submergence were more rapid in the north than in the south, the boundary of the extended Arctic Ocean might pass further to the south, and comprise, for instance, the northern part of the valley of the Mississippi, before the Gulf of Mexico extended its waters much to the north of its present boundary. In like manner, similar conditions might obtain during the subsequent emergence of the land. Minor hypotheses of this kind, entirely subsidiary to the general hypothesis with which they are associated, must be considered as always admissible, and can only be tested by observed phenomena. One remark, however, should here be made. The periods of greatest cold in America and western

Europe respectively could not, according to this theory, be *exactly* synchronous. Assuming, as we have done, the Gulf-stream to have existed during the supposed changes of level of the North American and European continents, it must have exerted its warming influence in the more northern latitudes, either as a direct current along the flanks of the Rocky Mountains, or as a reflected one on the western coasts of Europe. The cold due to the absence of its influence in both these regions could not be strictly simultaneous, although belonging to the same geological period. This is an essential conclusion of the theory. I know not whether there are any geological facts which tend either to favor or oppose it.

36. It only remains for me to say a few words respecting the hypothesis made in the early part of this memoir (§ 14, p. 78) of the continuity of land from the north of Scotland to the coast of Greenland. I have stated my opinion that the mean temperature along such a northern shore of the Atlantic might be increased 4° or 5° F., and that the winter temperature would probably be much the same on the coast of Iceland as in the latitude of central France. The climatal change might possibly be still greater than here estimated.

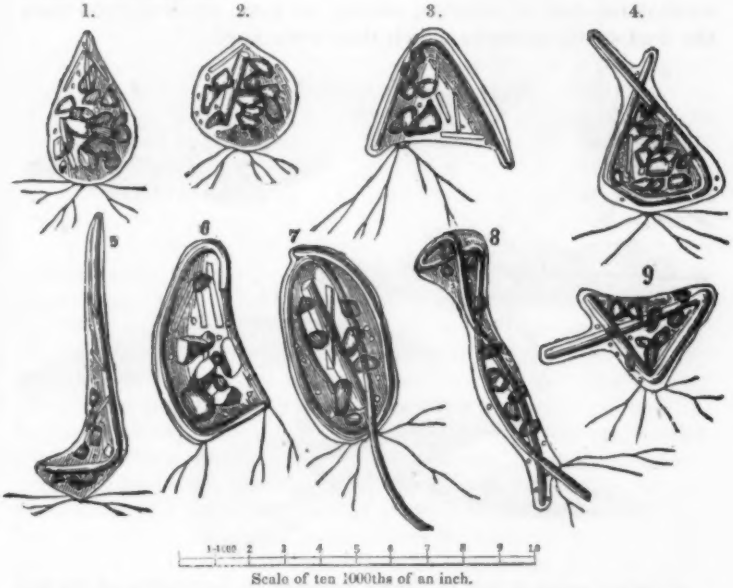
M. D'Orbigny has observed about a dozen species of sublittoral molluscs in the West Indies, which he regards as identical with species now inhabiting the western shores of the old continent in corresponding latitudes. Now admitting the theory of the dispersion of specific forms from single centres, this identity of species would imply some connection between these localities on opposite sides of the Atlantic, either by dry land or a shallow sea-bottom. I have already stated (§ 32) the grave difficulty which besets the hypothesis of a barrier of land across the Atlantic, and a similar difficulty must attach to the hypothesis of a shallow sea-bottom. The continuity of the northern shores of the Atlantic warmed by the Gulf-stream may possibly enable us to avoid the far more difficult hypothesis just mentioned. I merely suggest this hypothesis, however, for the consideration of those who may adopt the above opinion of M. D'Orbigny, and draw from it the inference of a former connection between the localities in which the identical species are found.*

* A note will be found towards the close of this volume on the isothermal chart illustrating this paper, issued with our March number.

ART. XXXVIII.—*Observations on a newly discovered Animalcule;* by J. W. BAILEY.

THE animalcules described in the following pages were found in great numbers in the bottom of a small vessel or "aquarium," in which colonies of Plumatella, Melicerta, and Limnias had been kept. Of all the forms which can with certainty be referred to the animal kingdom, there are few which at first sight are so little likely to be recognized as animals as those about to be described.

If the reader will imagine a bag made of some soft extensible material so thin as to be transparent like glass, so soft as to yield readily by extension when subjected to internal pressure, and so small as to be microscopic; this bag, filled with particles of sand, shells of Diatomaceæ, portions of Algæ or Desmidieæ, and with fragments of variously colored cotton, woolen, and linen fibres, will give a picture of the animal; to complete which it is only necessary to add a few loose strings to the bag, (figs. 1 and 2,) to represent the variable radiant processes which it possesses around the mouth.



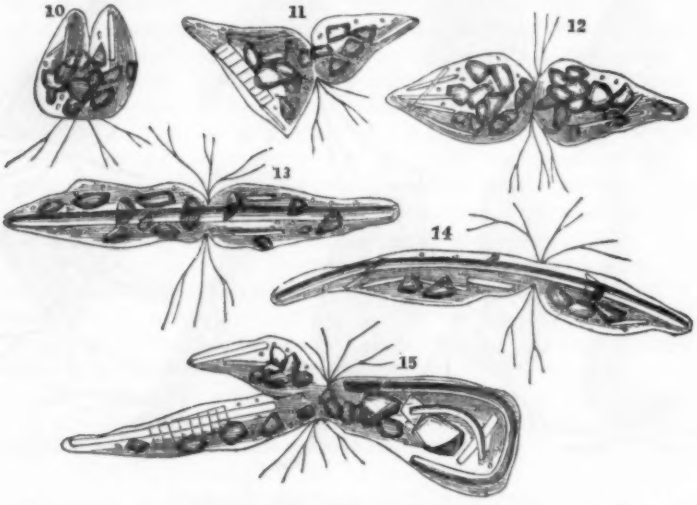
Scale of ten 1000ths of an inch.

When I first saw these curious creatures they attracted but little attention, as I supposed they were merely excrementitious masses due to some of the aquatic animals living in the vessel

where they occurred. A more careful examination showed that they moved spontaneously and even with some degree of rapidity; and that this motion was due to radiant, branching, and variable feelers, or "rhizopods," which were thrown out near one extremity. By attaching these feelers to various objects the animal was enabled by means of them, to pull itself along, or to change its position at will.

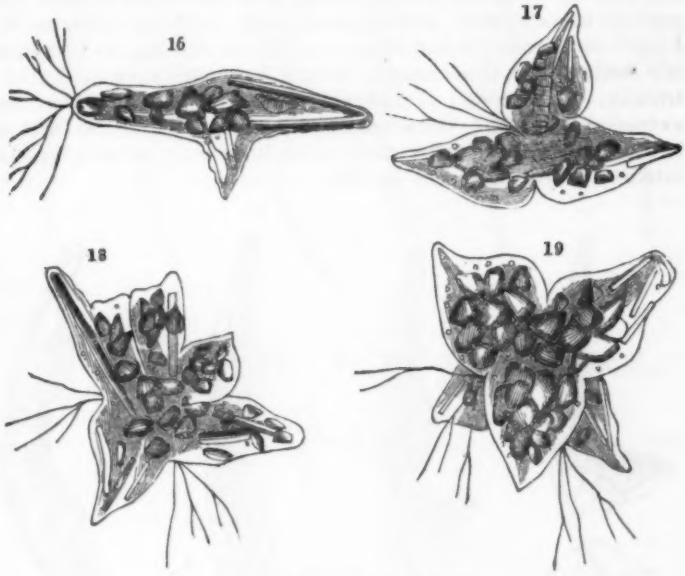
The most common form in which these creatures occur is that of a pear-shaped mass (fig. 1) having the feelers attached to the larger end, while the other end appears almost always to be pushed out and rendered acute by the presence of several long diatomaceous shells which the animals have swallowed. A globular or pyriform state (figs. 1 and 2) may be considered as the normal condition of these creatures; but the imagination can scarcely conceive of forms more varied and extraordinary than they assume in order to accommodate themselves to the shape of substances which they may have swallowed.

A better idea than words can convey of these bizarre shapes will be obtained by a glance at some of the figures, (figs. 3, 4, 5, 6, 7, 8, and 9, on the preceding page,) in which are represented various individuals in the shapes they presented after swallowing bits of woolen, cotton, or linen fibres derived from the dust of the room in which they were kept.



Another curious set of forms appears to be produced by the process of spontaneous fission or self-division, for I know not in what other way to explain such forms as those represented in figs. 10, 11, 12. It will be seen that these figures show what

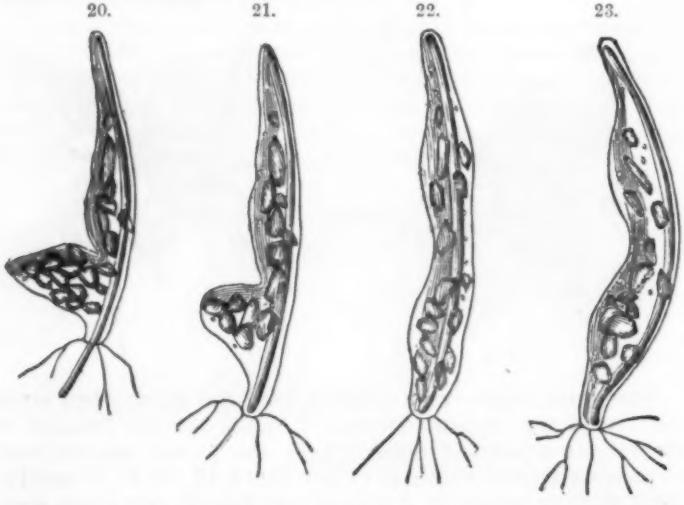
appear to be all the stages of fission from a slight depression in the posterior portion as in fig. 10, to an almost complete separation into two individuals, as in fig. 12, where a narrow isthmus alone connects the two portions. Although these successive states have not as yet been seen to occur in the same individual, I think the figures just referred to leave little doubt that the process of spontaneous division so common among animalcules is possessed by the creatures now under consideration.



The partial fission, or a budding from the sides, when combined with the distortion produced by the internal pressure of the various articles swallowed, gives rise to the complex and extraordinary forms shown in figures 13, 14, 15, 16, 17, 18 and 19. Some of these appear as if several pear-shaped individuals were about to be produced by a budding from the sides of the parent, but it is also certain that some at least of these sac-like projections are only temporary extensions produced by internal pressure. This was decided beyond a doubt by a series of continued observations upon single individuals, one of which, while swallowing a thread, was seen to assume successively the forms represented in figures 20 to 23, and another one while disgorging a thread changed shape as shown in figs. 24 to 31.

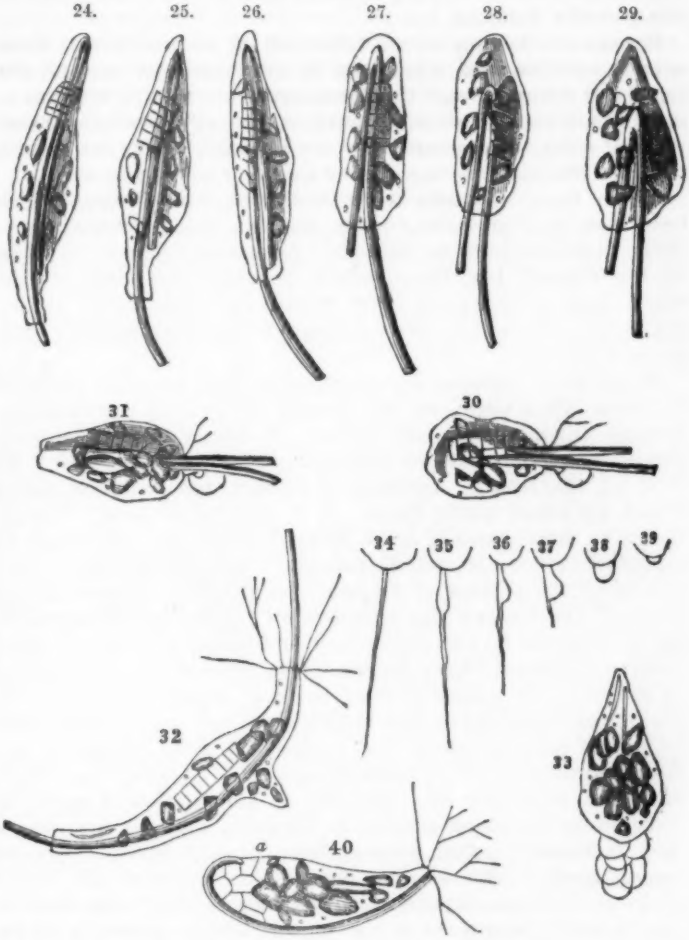
The substance of which these animals are composed is much like that composing the bodies of the various species of Amoeba, being soft, colorless, elastic and extensible. It is probably with-

out any true integument, and is colored yellow by tincture of iodine. It appears to resist internal pressure with considerable force, and it is but rarely that it appears to be completely broken through by any of the matters, however hard, which are contained within it. I have however found some individuals, as represented in fig. 32, which had voluntarily impaled themselves upon long fibres which were distinctly seen projecting through the animalcules at each end, and these animals were seen moving freely along from one end of the fibre to the other without appearing to experience any inconvenience from the perforation. I have occasionally found them attached in this way to filaments of Conferva and Draparnaldia, which were still alive at one extremity. The traces of internal structure or organization are exceedingly slight. Occasionally, when a portion of the body is left vacant, some slender thread-like lines may be seen in the interior, as shown at *a* in fig. 40.



In many individuals, (see fig. 33,) I have seen the protrusion from the mouth of transparent rounded masses, which rapidly succeeded each other until they were heaped up about the mouth like a set of soap bubbles and were then as rapidly drawn in again. The more common appearance however is that shown in most of the figures in these pages, where the mouth is surrounded by a considerable number of slender, colorless, radiant, branching, and retractile feelers, precisely like the rhizopods belonging to the marine Foraminifera or Polythalamia. When fully extended, these often exceed in length that of the body of the animal. They change rapidly from simple to branched, or

vice versa, and are at one moment seen in a state of tension, fig. 34, and then wrinkled and collapsed, as in figs. 35 and 36, or changed into various rounded processes (as in figs. 37 to 39) which can be wholly retracted. In figs. 34 to 39 are shown



some of these changes which were seen to take place in succession upon a single tentacle. These feelers, tentacles, variable processes or rhizopods are not like the pseudopods of Amoeba, mere protrusions of the surface, nor are they thrown out as in that genus from all parts of the animal. They on the contrary resemble those of a Difflugia in being confined to the vicinity of

the mouth; but they are much more slender and more repeatedly branched than in any Difflugia which I have seen. By means of these organs the animals pull themselves along, when lying upon their side, and they also creep by means of them, with the mouth downwards, moving onwards with a slow gliding motion like that of a Difflugia.

Besides the heterogeneous collection of matters which these animals swallow, and which can be seen distinctly with all the forms and colors through the transparent exterior, there is also in most specimens a considerable number of small globules scattered without order, whose nature is very doubtful, for as yet there is no proof whether they are ova, oil drops, or something else.

When these creatures have swallowed bits of fibres which have been dyed of various colors, the reds, blues, scarlets, &c. of these filaments may be distinctly perceived through the sides of the animal, but the spectacle becomes still more curious when seen by polarized light, when the particles of quartz, &c. contained within these creatures also display their gorgeous tints.

When these creatures are dried upon glass, and then mounted in balsam, their forms are not greatly altered, and their contents become still more distinctly visible. It seems scarcely probable that these animals have so little discrimination as to swallow for food all the strange mixtures of organic and inorganic bodies which are found within them. It is possible, however, that adhering to these grains of sand, fibres of wool, &c., there may be nutritive matters deposited from the water, which may be removed by the process of digestion, as the soft contents of the shells of Diatomaceæ also appear to be. This view is supported by the fact that on the application of tincture of iodine to these animals, a distinct blue color was often seen all over the surface of many of the grains of sand in their stomach. The starch giving rise to this color was doubtless derived from bits of boiled beans and potatoes which had occasionally been introduced into the aquarium as food for other animalcules. Another fact which appears to show that the sand, &c. is not swallowed merely to increase the absorbing surface, as Dujardin suggests may be the case in Amoeba, is that these particles of sand are not retained for any great length of time, but in company with the empty shells of Diatomaceæ, and other remains of their food, they are after a while thrown out at the mouth, which appears to be the only aperture for their reception and discharge. There appears to be no reason to doubt that the cavity into which all these bodies are received, is a true stomach, and they therefore manifestly cannot be considered as polygastric animals. As to the position of these creatures in the system of Zoology, it is evident that they belong to the Infusorial Rhizopoda of Dujardin, and

connect the genus Amoeba with Difflugia, agreeing with the first in the soft body without shell, but differing in having true feelers or rhizopods confined to the anterior portion of their body, and by not throwing pseudopods from other parts. From Difflugia and the whole family of Arcellina, these forms are distinguished by having no lorica or shell. They are, however, closely allied to the Arcellina, and are very nearly what some of the species of this group would be, if deprived of their rigid external coverings.

In order to give to these curious beings at least a temporary name and place, I propose to found for their reception a new genus named and characterized as follows, viz:

PAMPHAGUS, nov. gen.

Animals of the class of Rhizopoda (intermediate between Amoeba and Arcellina) without shell or lorica, and composed of a soft colorless matter easily extended by internal pressure, but not spontaneously protruded into pseudopods. Feelers or rhizopods, slender, numerous, radiant, branching and confined to the neighborhood of the mouth.

Species 1. *Pamphagus mutabilis*.—This species, which is the only one now known, is sufficiently described above. Its habitat is probably the bottom of small pools and streams of fresh water, as it was found in vast numbers in an aquarium supplied from such places in the vicinity of West Point. It will probably be found to be a common form, and as it presents the conditions of animal life in almost the lowest degree of simplicity, and can be preserved and studied with great ease, it will well reward the attention of microscopists. I have thousands of these animals now living in mid-winter, and with a little care they may probably be kept until the return of warm weather, when other interesting facts may possibly be added to the observations here recorded. The sketches above given, except figs. 34 to 39 inclusive, are all drawn to the scale on page 341, which shows ten one-thousandths of an inch equally magnified with the drawings. These sketches were all made by means of a camera lucida eye-piece attached to the microscope. The objective employed in making these drawings was a new one of surpassing excellence, of $\frac{1}{2}$ inch focal distance, made by Spencer.

West Point, N. Y., Jan. 14, 1853.

ART. XXXIX.—*A Consideration of some of the Phenomena and Laws of Sound, and their application in the Construction of Buildings designed especially for Musical Effect;* by J. B. UPHAM, M.D., Boston.

(Continued from p. 226.)

WE have treated of reflection and echo, in their relation to our subject, in a preceding number of this Journal. Intimately connected with, and yet distinct in some points from these attributes of sound, is reverberation. By it we understand that prolongation of the sound in buildings, as if it were rolled about long after the original impulse and its ordinary reflections have ceased. This seems to us to consist of the *residuary* sound, or that portion of the sonorous wave which is neither absorbed nor reflected, but which, adhering to the walls of a room, is rolled along their surface till it gradually dies away. The action of light impinging against a wall, under certain conditions, will, perhaps, aid us to understand this. When a ray of light is incident on the surface of any transparent, uncrystallized medium, a portion of it is reflected, another portion of it is absorbed, and the remaining part is *dispersed* in all directions, and serves to render the surface visible.

Just so it would appear to be in the case of sound impinging against any plane surface. From this hypothesis we should infer that rounded corners and arched ceilings would facilitate the progress and keep up the prolongation of this residuary portion. Such conditions we find *are* actually favorable to the greatest amount of reverberation; and what is stronger proof of the truth of our position, it takes place, oftentimes, in an apartment too small for the injurious effect of direct reflection. A striking case in point is found in the arched recitation rooms of Girard College in Philadelphia. These rooms, eight in number, are fifty feet square in the clear, and twenty-five feet high, with solid walls, smoothly finished, and an arched ceiling extending over each in the form of a dome. We visited these rooms in 1846, while the college was in process of construction, and then ventured the prediction that they could never be made to serve the purposes for which they were intended, unless altered from their original form, owing to the excessive amount of reverberation engendered. This was found to be practically true, and measures have since been adopted to remedy the difficulty. In their original naked state, the prolongation of the sound in these rooms continued fully six seconds.*

* It is but justice to state here that the consequences of this mode of construction were fully appreciated by the architect, Mr. Walter. In his final report, speak-

On re-visiting the College the present season, and repeating our experiments in these rooms, we found the effect of the remedial measures adopted to be remarkably striking. In one room, which had been treated simply by papering upon the solid walls and extending festoons of cotton cloth from the apex of the dome to the corners and centre of the cornices in each side, the reverberation was reduced to four and a half seconds; and in others, in which a partition of cloth was stretched across the room horizontally, from the opposite cornices, thus completely shutting off the arched ceiling of stone, and substituting a level surface of yielding canvas, its duration was only half a second. By whose suggestion these simple contrivances were tried, we could not learn, but presume they originated with the skillful architect of the building.

Another argument that such is the nature of reverberation, is derived from the fact that those apartments found to possess the quality of a whispering gallery, (which is generally explained on the principle of the conduction of sound along the surface of the walls and ceiling,) are always domed or of ellipsoidal shape, and they are those in which the reverberation is also greatest. Among the most celebrated of these is that of St. Paul's Cathedral, (a circular and domed apartment about one hundred and twenty feet in diameter,) in which a whisper is conveyed two or three hundred feet. The shutting of a door produces a rumbling like distant thunder. The rotunda of the Capitol at Washington is ninety-six feet in diameter and ninety-six feet high, the dome of which is a fine whispering gallery. The reverberation in this apartment is such as wholly to destroy the articulation of the voice at a slight distance. The principal room of the Merchants' Exchange in New York is of a similar character. When, as is often the case, an auction is being carried on in some part of it, it is utterly impossible to distinguish the words of the speaker at more than a few yards distance. In the vestibule of Girard College, which extends upward the whole height of the building, having two wings, each surmounted by a dome, a powerful and shrill note of the voice is prolonged more than ten seconds after the original sound has ceased. In the vestibule of the Boston Atheneum, which is similarly constructed, with but one wing however, the reverberation is four and a half to five seconds.

The recollections of a visit to Weyer's Cave in Virginia, in the summer of 1843, are still fresh in memory. The principal apartment here (called Washington's Hall) is two hundred and

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ing in reference to the excessive reverberation of these rooms, he says: "They are, however, constructed in exact accordance with the will, and these results were anticipated in the earliest stages of the work; but as Mr. Girard left no discretionary power in reference to this part of the design, we were compelled to take the letter of the will as our guide, let the results be what they might."

seventy feet long by from twenty to thirty broad, and fifty feet high. Says an enthusiastic writer, in describing this apartment:

"The curious explorer now witnesses something amazingly sublime. The walls are strung with musical colums which, by moving a stick over them, will produce a confusion of discordant sounds. The drum, the tamborine, the organ, are each represented and their notes, discordant heard alone, together aid the full concert, while the sound-board roars its melancholy murmur through the whole. But to attempt to describe what is here seen and felt is quite in vain; nor can any person form even the faintest idea of the sublimity and grandeur of this subterranean abode until he witnesses its magnificence, nor then can he find language copious enough to express his emotions."

This is no exaggeration. As is well known, this cave is formed in calcareous rock, and abounds in huge, irregular, and grotesque apartments, extending out, in every direction, into recesses and galleries, and crowned with lofty domes and inverted spires. In almost every part of the cavern, sounds of medium loudness are multiplied, prolonged and intensified to a degree that is absolutely terrific. But a few days subsequent to our visit, this cave was illuminated by two thousand lamps, and a band of music made to perform in one of its most resounding portions. Much have we regretted since, that it was not our fortune to be present on so unique and sublime an occasion. To the eye, the effect must have been indescribably grand, while, to the ear, as we can readily conceive, such commingling and prolongation of successive sounds, though in themselves musical, would bring one vast and overwhelming discord, which could be likened only to the fabled bellowing of the mountains in agony.

"Hic vasto rex Æolus antro
Luctantes ventos tempestatesque sonoras
Imperio premit, ac vinclis et carcere frenat.
Illi indignantes magno cum murmure montis
Circum claustra fremunt."

Some experiments made by the writer in the main apartment of the Boston Music Hall, while its interior was undergoing the various stages of finishing, are, in this connection, both interesting and important. This room is 130 feet in length, by 78 in width, and 65 feet high. After the floor had been laid, and the walls and ceiling furred off and lathed all around, preparatory to the reception of the plaster, the amount of reverberation was found to be inconsiderable, while a good degree of resonance was furnished by the solid masonry which formed the main body of the walls. The operation of plastering was done with despatch; and while in its recent state, being roughly finished and still soft and moist, the reverberation of the hall was at its minimum, and its resonance at the same time almost wholly gone. Heard under these conditions, the articulations of the voice were

exact and distinct, but there was an absolute *deadness* to its tones necessitating the greatest effort on the part of the speaker, so much did the sound seem to be swallowed up by the soft coat which completely enveloped it. The effect was literally that of a wet blanket thrown over both speaker and hearer. Day after day, as the layer of plaster hardened and dried out, both the resonant and reverberatory qualities of the room returned with increasing intensity. There was a period when it seemed as if these two properties (always to some extent antagonistical) were satisfactorily balanced, the former being sufficiently strong, while the latter was not unduly prominent. But such a state of things was of transient duration. When the composition upon the walls and ceiling was made smooth, and had become completely hardened, reverberation was very much in the ascendant, though still, in a measure, checked by the staging which filled up the interior of the hall like a forest of masts. On the removal of the staging, a powerful tone of the voice was prolonged four to four and a half seconds. This was when the room was empty, and completely devoid of upholstery and carpeting. When the floor of the main hall and balconies was covered with benches, having cushioned seats and backs, the aisles carpeted and the semi-circular windows near the ceiling shielded with curtains of canvas, the change was very marked, and the presence of a moderately large audience so completed the cure as that no injurious excess of sound remained. Should it be required, on any occasion, to reduce still further this reverberatory property, it can (in the opinion of the writer) be readily and perfectly accomplished by the use of additional upholstery, and the adoption of a simple contrivance with canvas, placed against the walls just below the cornice, which would not appreciably interfere with the resonance of the room, nor mar, to any extent, its architectural beauty.*

Mr. J. Scott Russell, whose opinion, in almost all matters of scientific enquiry, is entitled to profound respect, has adopted a different view of the nature of reflection and reverberation from that here expressed. In a discussion upon this subject at a meeting of the Royal Institute of British Architects in March, 1847, Mr. Russell contended that, contrary to the generally received notion of sound being reflected in a manner the same as light, it is

* The writer has recently been consulted with reference to the acoustic defects of the new Town Hall in Weymouth, Mass. The size of this hall is about 80 feet by 56, and 28 feet in height. It has perfectly smooth walls and ceiling. There are three windows on each side. It has no drapery or upholstery whatever. The reverberation is represented to be so great as to render the building wholly unfit for the purposes for which it was intended. Some measures were recommended for its improvement, the success of which remains to be seen.

The reverberation in St. Paul's Church, Boston, which is usually very considerable, is so checked by the customary decorations of the Christmas season, that the utterance of the speaker is then much more distinct than at other times.

thus reflected from a plane surface, only when the angle of incidence is greater than forty-five degrees, whereas, if the sonorous wave is incident on a surface at an angle less than forty-five degrees, it suffers little or no reflection, but is moved along in close proximity to the plane against which it is projected, and thus gives rise to the phenomena of reverberation. Mr. Russell derives from these supposed facts some practical suggestions, which he deems important in the construction of buildings intended for public speaking. Such rooms, he contends, should be so arranged as to avoid, as far as possible, all surfaces at right angles to the direction of the sound, and substitute those in which the incidental angle shall be less than forty-five degrees. Those surfaces, he continues, which must, of necessity, be at right angles to the sound, should be as far distant as possible. He suggests, also that in large rooms of quadrangular shape, the speaker, to be heard distinctly, should place himself near one corner, and direct his voice diagonally across to the opposite corner: that it is better, as a general thing, to speak from a point near a wall or pillars than from a distant point; and that, in a room of common form, it is better to speak along its length than across it. These maxims he lays down in order to avoid (on his theory) the undue reflection of sound. To check reverberation he enjoins the use of pilasters, placed at frequent intervals along the sides of the room, that the impulses, which strike the wall at an angle less than forty-five degrees and traverse its surface, may thus be broken up and destroyed, as waves moving upon water are arrested and broken up by the projecting posts of a pier.*

Mr. Russell further says that, though, in his own mind, he is convinced the action of sound, in these particulars, is in accordance with the manner just stated, he can offer no philosophical explanation of the facts. A writer in an English Journal, however, has offered the explanation of Mr. Russel's theory, which he himself declined to undertake. But, as the reasoner grounds his argument upon the assumption, at the outset, that the wave of sound may be considered a force of *continuous progression*, while such is not the case with a ray or wave of light, (a difference, the existence of which we must deny in toto,) we will not delay, in this connection, to follow out and refute his reasoning.

It is satisfactory to us, that the doctrines we have adopted in regard to reflection and reverberation of sound are strong in their analogy to the known laws of light, in its similar phenomena; and, while on this ground, we can equally well explain the more important maxims deduced by Mr. Russell, we will not, now, seek to disturb those harmonious relations of sound with light,

* The walls of the Boston Music Hall are thus treated, and the ceiling is deeply pannelled.

that we have found to exist, in so many other respects, between these two mysterious and all-pervading elements in nature.

Hitherto our attention has been directed mostly to the facts and principles which we conceived to be connected, more or less intimately, with the question at issue. We come now to the practical application of these facts and principles in the architecture of a building designed especially for musical effect.

Doubtless the conditions most favorable for the distinct perception and full appreciation of music, are to be found in the free air, where the medium through which the sound passes is without admixture, and nothing interposes or bounds, to alloy the purity of tone, to absorb, interrupt or dissipate the sonorous waves, or throw back upon the ear the disturbing influences of reflection or reverberation. There is no sublimer sound than the mingling of a thousand voices and instruments in an open field; so, on the surface of a lake, in a calm evening, music will seem to fill the air with a distinctness of utterance, and melt upon the ear with a delicacy, not elsewhere found. Handel knew this when he contrived his celebrated water music to gratify his sovereign, George I, whose anger he had incurred. But, in the nature of things, especially with a climate like ours, it is rare that music can be thus worshipped at her own shrine. Moreover the sensitiveness of many of the instruments which compose the orchestra at the present day, forbids their ever being used without injury in the open air.

In the construction of a Concert Room, therefore, our efforts should be directed to overcome, as far as possible, the imperfections to which every musical performance is necessarily subjected when confined within the four walls of a building. Theoretically, could we secure the ready passage and equal diffusion of sound over the whole apartment, without the intervention of reverberation or disturbing echoes, we should have a *perfect* Music Room, in every part of which the auditor would hear with equal distinctness and accuracy. How to approximate to this is the problem that here demands our serious attention.

In the discussion of this question, we shall consider the subject with reference to the following particulars, viz: Position, Shape, Proportion, Size or Capacity, Nature of Materials used and Mode of Construction for the walls and ceiling, Ventilation, Warming and Lighting, together with the details of the interior of the structure, so far as relates to the form and finish of its principal parts.

It seems almost superfluous, in this connection, to allude to the necessity of a retired position or other measures to exclude external sound, as an important requisite of a Concert Room. But these are points hitherto much neglected.

In every large city the multitudinous cries and sounds of busy life produce a constant discord, which the spirit of music seeks

to avoid. Much of the difficulty and annoyance complained of in the old House of Commons buildings, resulted from this cause alone.

The *site*, therefore of every building intended for musical purposes should be such as to exclude, as far as possible, all access to these external sounds, whether by direct communication or by conduction. If position alone will not secure this desideratum, much can be done, in aid of the object, by the proper construction of the building itself. It is advantageous, on this account, to have corridors extending completely round the room, thus cutting off all direct communication from without. Double walls and windows are also very efficacious in excluding noise. The number and position of the windows and doors is, likewise, important.

Attention to this particular is necessary, also, in the arrangement of the apertures for the admission of cold air from without for purposes of ventilation, as well as in the methods adopted for the escape of vitiated air, the product of respiration and combustion. In no case should these openings communicate directly with a noisy street or vicinity. Dr. D. B. Reid suggests,* when such connection is unavoidable, that all these openings be arranged in such a manner that while air is freely permitted to enter or to escape, the sound will have to be several times reflected in its passage, and thus be stifled or destroyed.

The proper *form* or *shape* of a room intended for sound has been a subject of much dispute.

On this point, the evidence of the witnesses examined by the Committee of the House of Commons is at variance. But in the case of the apartments in the Commons Buildings, submitted to the judgment of so many eminent architects and scientific men, there were peculiar difficulties to be overcome, resulting from Parliamentary habits of debate. There, as in our own Legislative Halls, the members speak from their places, and the speaker is an ever varying object with reference to the audience. It was required, therefore, to produce a room from every point in which a speaker could be heard with equal facility in all other parts. This it was that most seriously embarrassed the plans of all the architects summoned, and is sufficient to account for the great diversity of opinions expressed. In this form, indeed, it seems to us a problem incapable of being solved by any of the known principles of science. In a music room, fortunately, we have to deal with sounds which originate in but one portion of the apartment, and which are, therefore, far more within our control.

As to shape, the circular, the quadrate, the oblong, have all found their advocates. The principal argument in favor of a

* Reid's Illustrations of Ventilation; Art. Communication of Sound.

circular form is drawn from the fact that all the ancient theatres, Greek and Roman, are so constructed; the conclusion being that, had not this been peculiarly favorable to hearing, it would not have been so generally adopted. But, however much the Greeks and Romans excelled in their dramatic representations, and in the arts of eloquence and oratory, they knew little or nothing of music, as at present understood, and the use of the ancient theatre would ill comport with the requirements of a modern concert room. Both the player and the orator, in great part appealed to the eye in aid of the intended effect, while the ear unaided takes cognizance of music. In a large concourse, the circle, doubtless, combines more advantages for seeing than any other. But for distinct hearing the case is far different. For the reasons stated in the preceding pages, such conformation in the walls of a building is especially liable to reverberation or the prolongation of the residuary sound, an effect which is fatal to distinct hearing, and more than anything else, perhaps, mars the excellence of a musical performance. On the same principle we must reject the semi-circle, the oval, ellipse, and all other modifications of the circular form. So, also, should arched ceilings, rounded corners, domes, concavities and all curvilinear forms, in whatever part of the room, be discarded, as much as possible, as tending to augment the reverberatory power, and as having the effect, moreover, to collect and throw the sound in masses in different points, instead of allowing its equal diffusion throughout the whole apartment.

On the authority of the Rt. Hon. J. W. Croker, in his evidence before the House of Commons Committee appointed in 1833, the new Chamber of Deputies in Paris is sadly defective in its acoustic qualities. This room is semi-circular, having a chord-line of ninety-six feet, and is covered by a flatly domed ceiling. Said Mr. Croker, in reference to this apartment, "being doubtful whether it was not some defect in my own hearing, I made enquiries of several members, who confirmed my opinions of its being a very bad hearing house." He also makes similar complaints of the Irish House of Commons, which is a circle of about fifty-five feet, surmounted by a high spherical dome.

The quadrangular form is not liable to the objections above stated, but there is a greater lateral expansion and consequent loss of sound in a square room than in one of the same area whose length is greater than its width; hence, in a room of a parallelogram shape, a given sound will be conveyed to all parts of it with greater force than in the former case.

It is considered by many that, in a *small* room, the shape is of little or no consequence, as regards the sound, inasmuch as the ear, (say they,) cannot appreciate its defects. This is, no doubt, true in a room whose greatest diameter does not exceed fifty-five

feet, so far as direct reflection is concerned; but, as we have already observed, in the case of the recitation rooms at Girard College, which come inside of these measurements, the *reverberation* may yet be very great.

The Melodeon at Boston is imperfectly ellipsoidal in shape, with smooth walls and ceilings. Its length, width and height are, respectively, 113½, 57 and 35 feet. In the centre of the ceiling, which is flat, is an immense dome whose diameter at the opening is thirty-three feet. When moderately filled, as at the Musical Fund Society's rehearsals, the reverberation, as we have found by repeated experiments, is from two to two and a half seconds, a condition which is fatal to the distinct utterance of passages in music of even moderate rapidity.

The three most successful concert rooms in England are rectangular and oblong in figure, with rectilineal walls, joined by a coving of moderate extent to a flat ceiling.

The *proportions*, as well as the form of a music room, are not a matter of indifference. We have already noticed the tendency of one vibrating body or medium to throw another, in contact or in its immediate vicinity, into a similar state of vibration. In this way the oscillations of the contained air of a room, communicated to its walls, produce therein a sympathetic vibration, which will be more or less perfect according as the structure of these walls, their subdivisions and general relations of length, width and height, approximate to the acoustic conditions required. From this comes *resonance*, as we understand, the existence of which, to a considerable extent, in some rooms gives to the voice that peculiar brilliancy and resilient power which every singer must have noticed.

The experiments of M. Savart on the sonorous vibrations of solids are interesting in this connection, as showing the nature of resonance and how the original sound is thereby intensified, whether the resonant body is in actual contact with that producing the primary sound or not.* A ready illustration may be obtained by singing a note in the vicinity of a large drinking glass, and in the still more familiar experiment of speaking inside the mouth of a barrel. In both these cases the solid materials are put in vibration and impart a peculiar quality as well as intensity to the tone. Instances are on record where glasses have been broken in this way, by a powerful voice. To satisfy oneself that the vibrations are thus communicated in a well-constructed music room, it is only necessary to place the hand upon the walls during the performance of a symphony or chorus, and they may be felt.

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* Vide the Memoirs of M. Savart to the Royal Academy of Sciences of Paris, published in the *Annales de Chimie;* also Art. Sound, in *Encyc. Metrop.*, for copious extracts.

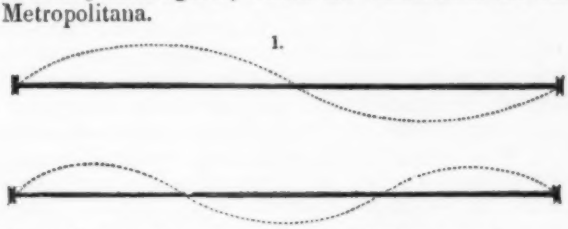
Mr. Gardiner long since suggested the observance of some definite form and proportions in the construction of music rooms. He recommended the figure of two cubes as a model. In this he derived his ideas from observation in the old cathedrals of Europe, which, he found, most approximated to this form, and among the finest music rooms in existence. More recently also, Mr. J. Scott Russell has advocated the use of aliquot parts of some common multiple, for the proportions, in length, width and height, of speaking and concert rooms, though upon what grounds we do not find distinctly stated.*

Our own belief is that we are to look for the explanation of these requirements simply to the phenomena exhibited in the vibration of musical strings and pipes.

Says Mr. Herschell:

"A cord, although vibrating freely, may yet have any number of points equally distributed at aliquot parts of its whole length, which never leave the axis, and between which the vibrating portions are equal and similar. Such points of rest are called *nodes* or *nodal points;* the intermediate portions which vibrate are termed ventral segments."

See the subjoined figures, which are taken from the Encyclopedia Metropolitana.



In illustration of the same point, he further says:

"If the string of a violin or violoncello, while maintained in vibration by the action of the bow, be lightly touched with the finger, or a feather, exactly in the middle, or at one third of its length, it will not cease to vibrate, but its vibrations will be diminished in extent and increased in frequency, and a note will become audible, fainter but much more acute than the original, or as it is termed the fundamental note of the string, and corresponding in the former case to a double, in the latter to a triple rapidity of vibration. If a small piece of light paper, cut into the form of an inverted V, be set astride on the string, it will be violently agitated, and, probably, thrown off when placed in the middle of a ventral segment, while at a node it will ride quietly as if the string were (as it really is at those points) at perfect rest. The sounds thus produced are termed *harmonics.*"

* The proportions of the Boston Music Hall, recently erected, are in accordance with Mr. Russell's views in this respect, being in length, width and height, respectively, 130, 78, and 65 feet.

But if a string, in the act of vibration, be touched at any other than these nodal points, its vibrations will be immediately confused and clogged. Precisely thus, in our view, is the case of the walls of an apartment. Here the whole extent of the wall, enclosing the four sides, may be regarded in the light of a vibrating string; and the angles of the wall should come in the points, required by the harmonic subdivision of the vibrating surface, which we have just seen must be placed at aliquot parts of its entire length. These angles would then mark the nodal points, or points of rest. And following out this reasoning, we would go still further and suggest that all the necessary breakages and interruptions by pillars, pilasters, doors and windows, should correspond with the nodal points in the wall, so as thus to interfere as little as possible with the free vibration of the whole, or its parts.

A room thus constructed will possess distinctly its key note, which every public speaker will find it to his comfort to seek out and regard.

But aside from these important considerations of position, shape, and proportions required in a structure of the kind proposed, *magnitude*, or a *large capacity* is indispensable to give to music its full power. The most sublime effects of the oratorio and symphony can only be produced in spacious buildings; this is independent of the number of the audience, and, in great measure, too, of the vocal and orchestral force employed. Mr. Gardiner was admitted to the rehearsal of the first grand performance in York Cathedral in 1825, when only five auditors were present. The choral and instrumental band consisted of six hundred performers. In one of his desultory volumes he thus speaks of that occasion:

"Upon the first burst of the voices and instruments on the words 'Glory be to God,' the effect was more than the senses could bear, so much was the sound augmented by the vast space of this noble building; nor was it till those overpowering concussions ceased that the imagination could recover itself."

And in another place, referring to the same subject, he remarks:

"Who has not observed the peculiar lustre imparted to a musical performance in a spacious church, which heard in other situations would give the ear no pleasure?"

Washington Irving, in his "Sketch Book," thus beautifully and with graphic power describes the effect of a sudden burst of music amid the vast silence of Westminster Abbey:

"The sound of casual footsteps had ceased. I could only hear, now and then, the distant voice of the priest repeating the evening service, and the faint responses of the choir; these paused for a time, and all was hushed. The stillness, the desertion and obscurity that were grad-

ually prevailing around, gave a deeper and more solemn interest to the place. * * * * * * *

"Suddenly the notes of the deep laboring organ burst upon the ear, falling with doubled and redoubled intensity, and rolling, as it were, huge billows of sound. How well do their volume and grandeur accord with this mighty building. With what pomp do they swell through its vast vaults, and breathe their awful harmony through those caves of death and make the silent sepulchre vocal! And now they rise in triumphant acclamation, heaving higher and higher their accordant notes, and piling sound on sound. And now they pause, and the soft voices of the choir break out into sweet gushes of melody; they soar aloft, and warble along the roof, and seem to play about these lofty vaults like the pure airs of heaven. Again the pealing organ heaves its thrilling thunders, compressing air into music, and rolling it forth upon the soul. What long-drawn cadences! What solemn, sweeping concords! It grows more dense and powerful—it fills the vast pile, and seems to jar the very walls. And now it is winding up in full jubilee—it is rising from the earth to heaven—the very soul seems rapt away, and floating upwards on this swelling tide of harmony!"

The commemoration of Handel, which took place in Westminster Abbey in 1784, forms one of the grandest musical epochs in history. This festival lasted five days, and was conducted in presence of the Royal Family and many of the nobility of the realm, and the public in general to the number of three or four thousand persons. The number employed in the instrumental and choral band amounted to between five and six hundred. In 1834, just fifty years afterwards, this festival was repeated, and in an account of it, a writer in the *Musical Library* speaks as follows:

"The nave of the Abbey is 150 feet long, and, including the aisles, 72 feet wide; its height 101 feet. This space was converted into a grand saloon, at the west end of which was erected the orchestra, rising from about eight feet from the floor to the middle of the great window; the principal singers and the instrumental performers occupying the nave part: the chorus filling the portion in the aisles up to the tops of the arches. In each aisle was built a long deep gallery extending from the orchestra to the royal boxes, and projecting from the wall to about three feet beyond the columns. The galleries contained several rows of seats, rising to the key-stone of the arches. The aisles below were fitted up in a manner similar to the galleries.

It is admitted that the performers, on the present occasion, excelled in every way those who formed the orchestra on the different festivals at the close of the last century. The force employed in the full pieces amounted to five hundred and ninety-one; and the band generally, both instrumental and vocal, can only be mentioned in terms of the highest praise. Yet those who heard the music in York Cathedral, in 1825, declare that, with about the same number of performers, but *in an area more than double that of Westminster Abbey, the effect was greater than that just witnessed in the capital of the kingdom.*"

But we need not go so far away for evidence and illustration in proof of our position. Who among those present at the late opening festival of the Boston Music Hall could fail to notice the peculiar mellow effect of Handel's "Hallelujah," and "The Heavens are telling," though rendered by a force of fifty instruments and five hundred voices?

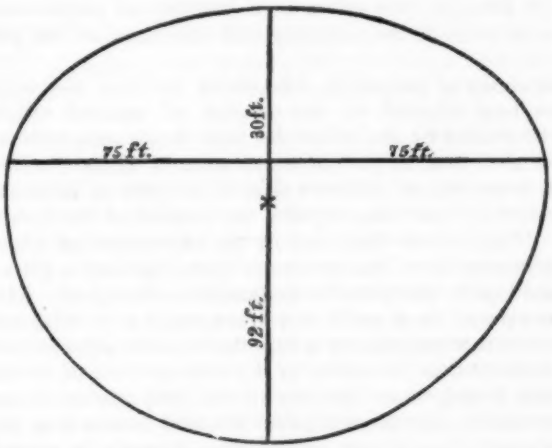
These effects, in the instances above mentioned, may be, in part, attributed to the associations of time and place, but in greater part, we contend, are they owing to the architectural qualities of the building. And the explanation is to be found, doubtless, in the fact before alluded to, that distance aids in fusing together and harmonizing musical sounds. Let any one, who is skeptical of this truth, but listen to a band of indifferent performers in the open air, on a summer's evening, first in close proximity to the players, and then at a distance, and he cannot fail to be convinced. It is the test of a good organ to throw out its sounds with fulness and opulence, into the body of a church, though on a near approach its tones may be meagre and thin. Thus sound requires *room* for its perfect development;—and as a rare painting, which on near inspection appears crude and unfinished, will ripen into harmony and just proportions when allowed its requisite distance, so, in the case of a musical performance, an ample space has, in itself, a mellowing influence upon the harshness that always exists in greater or less degree, seeming as it were to purify the sound in some measure of its inharmonious elements and suffer it to fall with richer effect upon the ear.

Thus far, in this connection, we have spoken only of orchestral and choral harmony; but it is a mistake to suppose that choral or orchestral floods of sound are required to fill such ample space, while the tones of a single voice therein would be embayed or lost. There is a lustre likewise imparted to the intonation of a single voice or instrument, in similar circumstances, when rightly managed, such as no narrow limits can give. We speak here of an apartment constructed in accordance with the principles previously given, in which the sound is not unduly absorbed, overpowered, wasted or confused.

According to the experiments of Mr. Benjamin Wyatt, it appears that the geometrical figure which comes nearest to the extreme limits of the natural expansion of the voice in speaking, is a semi-circle of seventy-five feet radius, continued on each side to the extent of seventeen feet, or in the proportions of about two-ninths of its lateral expansion beyond the limits of the semi-circle, and then converging suddenly until the two lines meet behind the back of the speaker; in other words, that the reach of the voice, when moderately exerted, was in the proportion of about two-ninths farther in a direct line than laterally; and that being distinctly audible on each side of the speaker at a

distance of seventy-five feet it will be as plainly heard at a distance of ninety-two feet in front of him, declining in strength behind him so as not to be clearly heard at much more than thirty feet. The following diagram will aid us to understand this; the position of the speaker is represented by the point of intersection of the straight lines.*

2.



The figure that would conform to these measurements it will be seen is an imperfect ellipse whose major and minor axes are respectively 150 and 122 feet. This is the space allotted to the sound in the ordinary exertions of speaking, and under the usual conditions of the atmosphere. We have seen, however, that, when the medium is in a state of absolute purity, vocal sounds are readily conveyed over an extent far greater than that just stated. We shall have occasion to allude to this point again when we come to the subject of ventilation and warming.

The calculations of Mr. Wyatt, we repeat, refer only to the power of the vocal tones in the ordinary efforts of articulate speech; but of the capacity of the human voice, when rightly exercised *in song*, to fill completely a space much larger than that above designated, we have no doubt. As noticed in a previous chapter, a musical tone reaches farther than other sounds of the same intensity; in illustration of which it is only necessary to instance the effect of the liturgy recited in the cathedrals abroad, where, as must have been often observed, the mass, which is performed in musical tones, becomes audible in the remotest part of the church, whereas, had the same service been read, the

* Vide Gwilt's Encyclopedia of Architecture.

sound would have been wholly lost. The tones of a Cremona violin which were not conspicuous in the rank and file of the orchestra, have been observed to stand out with singular prominence and beauty as the hearer receded to a distance. It follows, as a corollary from this, that a perfect intonation of voice or instrument is required to insure its legitimate and full power, and in this particular, as has been truly remarked by a keen observer, (Mr. J. S. Dwight,) the effect in a building of proper construction is a measure of the accuracy and excellence of the performance.

In our *choice of materials*, wherewith to form the walls of a structure best adapted for the display of musical effects, we should be guided by the principles laid down on a former page. We have seen that, in the communication of vibrations from one medium to another of different density, a want of homogeneity, in the receiving medium, impairs the quality of the transmitted sound. This is well illustrated by the experiment of Chladni in the communication of the sonorous vibrations from a glass to the contained liquid, when its homogeneity is disturbed. Here the sound is excited in a solid and transmitted to a fluid medium. Conversely, this experiment is repeated upon a larger scale whenever a musical tone is excited in the contained air of a room.

We also found, when treating of the propagation of sound in different media, that the resonance of solid bodies is in the ratio of their conducting power, which latter depends, in great degree upon hardness and elasticity, and uniformity of structure.

In the proper structure and conformation, therefore, of the walls and ceiling of every musical room, are found the primary conditions of its resonance and perfect intonation. Reasoning from the data afforded in the vibration of musical strings, we have previously enjoined the use of harmonic measurements in the general proportions and subdivisions of such rooms, for the securing of the free vibration and consequent resonance of the whole and its parts. But this is presupposing such unity of structure as before mentioned, without which no harmonic proportions would produce the intended results.

In the selection of materials for building we are of necessity limited to wood, brick and stone. Of the woods, various species of the pine appear to be among the best resonants and conductors of sound, and are therefore well fitted for our purpose. Should a building be entirely constructed of this material (we have no reference here to a mere lining of wood) it would doubtless best answer the end in view. But the greater expense and risk attending this mode of building will prove a sufficient objection to its use.

Between brick and stone, there seems to be but little choice. By the preceding considerations, however, we are led to the

opinion that the one or the other should alone be employed, and that the substance used as a cement should partake of the nature of the solid material, that thus the whole mass may more nearly resemble a uniform structure. In this connection arises the question as to the proper finish of the internal face of such wall, this being the surface presented to the sound.

(*To be continued.*) Vol 18 p 21

ART. XL.—*Notice of the Meteoric Iron found near Seneca River, Cayuga County, N. Y.;* by CHARLES UPHAM SHEPARD, M.D.

THIS iron was very briefly announced in the November number of this Journal (vol. xiv, p. 439,) by Prof. O. Root of Hamilton College, Clinton, N. Y. The weight of the mass was between eight and ten pounds. It was picked up by a farmer, while engaged in excavating a ditch; his attention having been arrested by its unusual weight, as compared with ordinary stones. A thick coating of limonite (hydrous oxyd of iron) formed the entire outside of the mass. Its general figure was somewhat drop-shape; although the customary depressions found on the surfaces of meteorites, were visible also, in the present instance.

I am indebted to Prof. Root for a very perfect tetrahedral fragment (of about two ounces weight) which must have formed the little end of the meteor; and to LeRoy C. Partridge, Esq., of Seneca Falls for a thick slice (of four and a half ounces) which apparently, is a section across the mass, next below the above.

The figure here given represents the broadest face of the latter specimen, with the Widmannstättian figures, as developed by hydrochloric acid on a portion of its surface.

The broad, unshaded bars, which meet at angles of 60° and 120°, are quickly brought out by the acid, their own surfaces not being corroded in the slightest degree by the chemical action, which is confined to the linear intervals between the bars, to the triangular and rhomboidal patches which are shaded in the drawing, and to the borders of the very circumscribed and irregular areas, situated upon a few of the bars themselves. These regions are completely covered during the operation, with little bubbles of nearly pure hydrogen gas.

After the corrosion has been permitted to go on for a number of minutes, the linear intervals above mentioned, exhibit a checked appearance, as if a single row of little prisms had been inserted between the broad bars. These prisms evidently consist of the same alloy as the broad pillars, between which they are thrust, since their tops, like the surfaces of the bars, escape corrosion, and are left after the action has ceased at the same level with the bars themselves. Their presence, in the peculiar position they occupy, confers upon this iron a very remarkable feature, totally unlike any other I have seen. Indeed in all other highly crystalline specimens, we have a series of perfectly continuous lines and edges, in place of the checkered rows here displayed.

The shaded triangular and rhomboidal areas, when their surfaces are well cleaned by a dilute aqua regia (and polished), and examined under a lens, are seen to be finely striated with the same beaded or checkered lines as those above described in the linear intervals.

The more circumscribed areas (three of which are represented in the central bar of the figure) consist of a silver-white mineral, believed to be new; and which will be more particularly described farther on. This substance is not acted upon by the hydrochloric acid; but an envelop of meteoric pyrites, by which it is more or less surrounded, is briskly attacked: and from these regions the odor of sulphuretted hydrogen is plainly perceived. At a place marked A in the figure, is a semicircular vein of this white mineral, where the pyrites is quite abundant.

The want of continuity in the larger bars and their rounded terminations also, serve still farther to distinguish at first glance, the Seneca River iron from nearly all others.

A solution of sulphate of copper dropped upon a moistened surface of the iron, immediately gives rise to a precipitate of metallic copper. It is therefore not in the passive state of the Greene county (Tenn.) iron, and of some others, as discovered by Wöhler.

Beneath the coating of limonite is found a very distinct layer of compact, black magnetite, which must have constituted the original crust of the meteor. Its thickness in some places is $\frac{1}{10}$th of an inch. The specific gravity of the iron is 7·337.

It possesses a medium hardness, and takes a very high polish, having the customary greyish white tint. In this respect as well as in many other particulars, it differs widely from the Burlington iron,* which is remarkable for its whiteness. The tendency to cleavage in the Seneca River mass is very obvious; and when

* The Burlington iron was found 90 miles to the eastward of the present mass.

torn asunder, in place of presenting a hackly fracture, leaves surfaces with pyramidal cavities and projections.

Analysis.—The iron dissolved very slowly in cold hydrochloric acid, attended by the extrication of hydrogen gas, along with which, sulphuretted hydrogen was occasionally evolved,—as became apparent by passing the gas through a solution of nitrate of silver. As the solution proceeded the surface of the iron became coated with a brownish flocculent matter, resembling somewhat the development of carbon on steel by nitric acid. These flocculi at length separated from the iron, collected into light coherent masses, and floated about in the liquid,—discharging little bubbles of gas, and subsiding finally in masses of much diminished size to the bottom, where they rested upon the broken crystals of the shining white, metallic mineral, above referred to.

As the solution proceeded very slowly, it was repeatedly quickened by a gentle heat, for half an hour at a time. Three days elapsed however, before the action of the hydrochloric acid was completed upon 50 grains of the iron. A second fragment of 20 grains was treated in a similar manner, and with the same general result.

Among the insoluble matter from the first fragment were found two very brilliant, black, octahedral crystals, whose weight together was only 0·005 of a grain. They were unmagnetic. Each of them was measured by the reflective goniometer, and clearly ascertained to be a regular octahedron. And as chromium was found in the acid solution of the iron, it cannot perhaps be regarded as an unauthorized assumption, to consider these crystals belonging to the species chromite, the more especially as this mineral has repeatedly been observed in meteorites, though never before, in well pronounced crystals.

The brown powder amounted, when dry, to 0·125 of a grain. It was partially acted upon by aqua regia; but in other respects appeared identical with that insoluble ingredient in several meteors which I have called dyslytite, and which besides a decided content of silicon, has iron, nickel, phosphorus, chromium and carbon, in some unknown combination.*

The remaining insoluble matter, the white (slightly bronze-colored) crystallized substance, whose weight was 1·05 p. c. of the iron, is a mineral which I believe to be undescribed, if not wholly new. It may have been seen before; but if so, it would appear to have been confounded with the foliated, metallic sub-

* The gradual shrinking of this flocculent matter under the long continued action of the hydrochloric acid, attended with the escape of gas, suggested the idea, that if nitrogen exists in these bodies, it might perhaps be detected here, as a solid, or rather as a pulverulent azotide of iron, nickel or chromium, analogous to the known azotide of copper, Cu^3N, dicovered by M. Schrœtter (Ann. der Pharm., xxxvii, 129). The same chemist has actually described an azotide of chromium. These compounds are decomposed by heat and by strong acids.

stance, which is also insoluble, and which has been called Schreibersite by Patera; though this designation cannot be maintained, inasmuch as I had previously called another meteoric mineral by this name.

I propose the name of *Partschite* for the substance now under consideration, in honor of the eminent Prof. Paul Partsch of Vienna, whose contributions to astrolithology in the description of the meteoric collection of the Imperial Museum at Vienna, have been so important to the progress of this interesting branch of knowledge.

Properties of *Schreibersite* of Patera.	Properties of *Partschite.*
H. = 6·6.	H. = 5·6.
Sp. gr. = 7·01—7·22.	
Magnetic.	Magnetic.
Color bronze-yellow.	Color silver-white, or only with a tinge of reddish-grey.
Elastic.	Brittle.
In thin plates.	In four-sided oblique prisms, with dihedral summits, whose faces correspond to the prismatic edges.
	Streak dark grey.
Composition.—Iron, 87·20; nickel, 7·24; phosphorus, 7·26; carbon ? = 98·70.	When powdered, quickly soluble in aqua regia. It contains iron, nickel, magnesium, and phosphorus.

The proportions of the different substances forming the Seneca River meteorite, as ascertained in the two analyses, were as follows:—

Nickeliferous iron, . . .	98·69
Partschite, (with trace of pyrites,) .	1·05
Dyslytite, ...	0·25
Chromite, ...	0·01
	100·00

The nickeliferous iron gave,

Iron, ...	92·40
Nickel, ...	7·60
	100·00

Chromium, magnesium, tin, manganese? phosphorus, sulphur, in *traces.*

Charleston, S. C., Dec. 24th, 1852.

Art. XLI.—*Notice of the "Mastodon Giganteus" of Dr. J. C. Warren.**

We have already briefly announced the publication of the magnificent volume on the "Mastodon Giganteus," by the eminent surgeon and scholar, Dr. Warren. Turning aside from the profession which he has honored by his profound knowledge and successful labors, he here enters the arena of Science, and substantiates his claims to a distinguished place among the Zoologists of the age.

Dr. Warren has the rare pleasure of possessing the noblest specimen of the Mastodon giganteus that has yet been discovered; and fortunate it is for the old mastodon, that it has found a final resting place with one who has had the generosity and ability to raise so munificent a mausoleum to its memory. A second skeleton was afterwards purchased by Dr. Warren, to aid him in his researches; and, for the same purpose, he has also added to his collection the skeleton of an elephant. This elephant—the one accidentally drowned a few years since in the Delaware—stands in his fine hall, by the side of the huge mastodon, and although a large animal of the kind, it is but a pigmy in comparison. Dr. Warren was thus well equipped for the prosecution of his researches; and no labor or expense has been spared, either in carrying forward his investigations or in the publication of his results.

The title page of the volume presents a view of the region near Newburgh on the Hudson, where the skeleton was exhumed. Among wooded hills lies a large morass, part of which in the front of the scene, has been excavated by the removal of the surface peat of the bog, and the subjacent marl, leaving the skeleton as it was found lying sprawling out, with the ribs and nearly every bone in place. The fore-feet extend beyond the head, and the hinder are thrown forward near the body.

It was in the summer of 1845 that this burial place of the ancient giant was first disturbed. The swampy land was then dry. Mr. Brewster, while digging in the place to obtain the earth for fertilizing his fields in the vicinity, after penetrating through two feet of peat bog, one foot of red moss, and a foot of the shell marl, struck upon the head of the animal. The exhumation went on rapidly the next day, and the cranium, "bones of the spine, tail, pelvis and ribs were successively found, for the most part in their natural relation to each other;" and at the end of the second day, nearly the whole skeleton had been exposed. The bones

* Description of a Skeleton of the Mastodon Giganteus of North America, by John C. Warren, M.D., &c. 219 pp. 4to, with a frontispiece and 27 plates in 4to. Boston: 1852. J. Wilson & Son, 22 School Street.

were in an admirable state of preservation. It seems from the position, Dr. Warren observes, as if the animal had stretched out its fore feet in a forward direction, to extricate itself from a morass into which it had sunk.

Even the undigested food of the animal appears to have been partly preserved. Dr. Prime testifies that* "in the midst of the ribs, imbedded in the marl, and unmixed with shells or carbonate of lime, was a mass of matter composed principally of the twigs of trees, broken into pieces of about two inches in length, and varying in size from very small twigs to half an inch in diameter. There was mixed with these a large quantity of finer vegetable substance like finely divided leaves; the whole amounting to from four to six bushels. From the appearance of this and its situation, it was supposed to be the contents of the stomach; and this opinion was confirmed on removing the pelvis, underneath which in the direction of the last of the intestines, was a train of the same material, about three feet in length, and four inches in diameter." The subsequent examination of a portion of this material by Dr. Warren, Prof. Gray, and Dr. Carpenter, supports the opinion here expressed; and both from this case and other examples of exhumed mastodons, it is shown that the mastodon lived on stems or twigs of trees; part of the material found was probably "some kind of spruce or fir."

Such are some of the facts which are here published by Dr. Warren concerning the discovery and food of the mastodon.

In his account of the animal, after his historical sketch, and some observations on the name of the species, he enters upon the description of the various parts of the skeleton, in detail; and excellent lithographic plates illustrate these chapters. One of these plates, of very large size, represents, in an admirable style, the entire skeleton. The following are some of the dimensions given:

	Feet.	In.
Height of skeleton,	11	
Length from anterior extremity of face to the commencement of the tail,	17	
Circumference of the trunk around the ribs,	16	5
Length of tail,	6	8
" " trunk,	10	3
" " head from the occipital condyles in a straight line to anterior edge of tusk-socket,	3	2
Entire length of tusk,	10	11
Depth of socket of tusk,	2	3
External length of tusk,	8	8

* p. 144.

There are 7 cervical vertebræ, 20 dorsal, 3 lumbar, and 5 sacral. The ribs are twenty in number, 13 true, and 7 false. From the 6th to the 11th their length is between 52 and 54¾ inches. The first has more the appearance of a clavicle than a rib, and is 28 inches long. Bearing on the number of ribs, Dr. Warren observes, (p. 31,)

"The last two false ribs on the right side are co-ossified for the space of 8 inches;—the result of a fracture near their vertebral attachments: the union of these ribs, at its broadest part, measures 8 inches. These bones are perfectly smooth within, and without are quite strong, at the place of union and massive. This fracture is of great importance, as by the union is verified the remark of Cuvier, who found only 19 ribs, but stated that there would, in his opinion, be hereafter found twenty—a fact entirely established in this specimen, first by the articular surface on the side of the 20th dorsal vertebra; and second, by the co-ossification of the 19th and 20th ribs."

After describing the several bones throughout the structure, the author treats at considerable length of the characters of the teeth. Those of the elephant are first described by way of comparison, their number (twenty-four exclusive of the tusks), composition, and form being considered. On taking up the odontography of the mastodon, the author commences with some general observations, and then proceeds to a minute account of each of the teeth in succession. Omitting the mass of details, we cite the following from his General Remarks, pages 61 to 64:

"While the teeth of the elephant are, as already said, composed of three kinds of hard matter, dentine, enamel, and cement, those of the Mastodon giganteus are constituted principally of two of these substances, dentine and enamel. Prof. Owen has shown that a layer of cement invests the fangs, and is spread over the crown, but the basis of the crown and of the fangs is formed by the dentine; while in the teeth of the elephant, and some others of the Pachydermata, the cement, by its perpendicular interposed layers, constitutes a substantial part of the body of the tooth, as well as a protecting covering to its surface. A great portion of the Mastodon tooth is formed by dentine. The mamillary eminences, or mastoid projections also have a basis of the same substance, but they are invested with a covering of enamel, which in molar teeth in my possession, measures from the sixth to the fourth of an inch in thickness. In teeth which have been worn, the enamel is ground down in various degrees; thus altering the surface of the crown to an appearance approximating, in the Mastodon giganteus, to the lozenge-shaped ridges of the African Elephant.

* * * * * * * * * * *

The number of the teeth was long involved in mystery. The genius of Cuvier opened the way to a knowledge of their number, differences and development. He advanced no farther in the path he had opened than to the fourth, or, at the utmost, fifth tooth; making the

whole number to be from sixteen to twenty, exclusive of the great incisors or tusks.

In 1831, Dr. Hays, the distinguished editor of the 'American Journal of the Medical Sciences,' read a paper before the American Philosophical Society, in which he described various jaws of the Mastodon giganteus, and the teeth contained in them. He seems to have been the first writer who clearly pointed out the probability that the number of these teeth was six on each side of each jaw in the Mastodon giganteus, and of course the whole number twenty-four. He says 'the whole number of teeth possessed by the animal described by Dr. Godman (Tetracaulodon) is then at least twenty; and we think that it is at least probable, that the animal possessed an intermediate tooth between the second tooth with three denticles, and that with four denticles. Should we be correct in our views, this animal possessed three teeth with three denticles in each side of each jaw, making the whole number of teeth twenty-four; but to render this certain would require specimens of intermediate ages to those hitherto described.' These have since been obtained, and have fully confirmed the opinion suggested by the sagacity of Dr. Hays. In the collection of the Cambridge University, there is a series of jaws affording a perfect demonstration of this fact, and settling the number to be twenty-four. Professor Horner, in a paper read to the Philosophical Society, thought that there might be a greater number. De Blainville makes them twenty-four.

The specimens in the collection of the American Philosophical Society, those of Cambridge University, various others in New York, Albany, and in my private collection, support the opinion that the number is twenty-four, and no more.

The teeth are not all developed at the same time, but in succession, in proportion to the waste of those which have preceded. At first appear two small deciduous teeth, or milk molars; next follows a third tooth, also deciduous, larger and more complicated than the former; then a fourth tooth, of the same form as the last, though greater in size. These four teeth sometimes co-exist, as in the Tetracaulodon's jaw, from the museum in New York, originally described by Dr. Godman, and afterwards more particularly described and represented by Dr. Hays in the 'Transactions of the American Philosophical Society,' vol. iv. To the teeth already mentioned succeeds a fifth tooth, of the same form as the last, but rather larger. Before the appearance of this, and even in most cases before the fourth tooth shows itself, one or more of the first teeth have disappeared. The sixth and last tooth is much larger, and formed in a mould different from any of the others."

The plates represent in beautiful style the dentition of several skeletons, exhibiting the jaws and teeth of different ages.

The *tusks*, which are *incisor teeth*, enormously developed, are treated of in the following chapter, as follows, pp. 87—90:

"Besides the regular intermaxillary tusks, there are two very small ones, which show themselves in the upper jaw at the earliest period of life, but shortly disappear and are succeeded by the permanent tusks. This is shown by cutting into the tusk-socket of our calf elephant head.

The fact well established in regard to the elephant, seems to afford presumption, that besides the great intermaxillary tusks of the Mastodon, there may be others in the upper or lower jaw, which appearing at an early period of life, are, in the greater number of instances, lost before the animal has advanced far in its existence.

In the present specimen of the Mastodon, there are two tusks in the upper and one in the lower jaw on the left side. Two undoubtedly existed in the lower jaw, at an early period of life, as the relic of the right cavity is perfectly distinct, retaining a depth of an inch and a half, and nearly its original diameter.

The Superior Tusks.—The tusks of the upper jaw were ten feet and eleven inches long; but being broken soon after exhumation, only the anterior termination of each (in length about four feet and in diameter at the truncated extremity five inches) remains in a perfect condition. The middle portion, rather more than two feet, has crumbled. The posterior portion, of about the same length with the anterior, is broken into laminæ; it is flattened at the base, so as to be half an inch longer in one diameter than in the other, making the largest seven inches and a half. The bases are surrounded externally by circular elevations, at first two inches distant from each other, but gradually increasing in distance, until, at about two feet from the extremities of the bases, they disappear entirely.

The tusk is composed of laminæ which at the internal extremity of the socket, are not more than a line in thickness. These laminæ increase in number as we advance from the butts, so that where the tusk issues from its socket at the distance of rather more than two feet from the posterior extremity, the internal cavity has diminished from seven inches in diameter to two by two and a half. The plates into which the tusk has separated in drying are generally an eighth of an inch in thickness, some of them nearly an inch. The external surface has a brown appearance; the layers which have been recently uncovered are of a lighter color.

The following analysis of a portion of the tusk has been kindly furnished me by Dr. Chas. T. Jackson:

'Animal matter (cartilage), ...	26·2
Phosphate and carb. of lime, fluorid of calcium, &c.,	69·2
Water, ...	4·6
	100·0

Glass was etched with the fluorine. The constituents of the tusk are phosphate of lime, carbonate of lime, fluorid of calcium, phosphate of magnesia, soda, sulphur.'

The laminæ at the anterior part of one of the tusks, which is best preserved, are superficially not more than half a line in thickness; they are divided or split by longitudinal fissures about three-fourths of an inch apart; and they present none of the circular marks seen at the posterior extremity. The point anteriorly is worn away for the space of two inches on one side, as is generally found to occur in the tusks of the proboscidian family.

When the tusks were first discovered, they lay with their convexities outwards, their points approaching each other; having apparently turned

in their sockets after the soft parts which retained them were decomposed so as to loosen their attachments. For the weight of the head inclined the butts downwards, while the resistance of the marl on their inferior and internal sides would give a rotary motion outward and upwards to a definite extent. In this direction they were placed by Dr. Prime, who had an opportunity of observing them in their original position in the embedding marl. Although the extremities of the butts are somewhat oval, the greater size of their sockets owing to the decomposition of the soft textures which lined them, would readily admit the butts of the tusks to be placed in any direction; and considering the apparent inutility and the remarkable anomaly of the position before mentioned, we thought it right to change their opposing aspect to one more consonant with the character and attitude of the skeleton.

The Inferior or Mandibular Tusk.—The small mandibular tusk has been brought into notice of late years by Dr. Godman, who considered it as characterizing a new species, to which he gave the name of Tetracaulodon, as will be shown hereafter. Professor Owen has attached a new importance to this tusk, as one distinctive character between the genus Mastodon, and the genus Elephas; a distinction which M. de Blainville, Dr. Falconer and others, have been willing to pass over. But hitherto, so far as we know, the existence of this part in the elephant has not been discovered; while it is perfectly established in regard to the principal species of Mastodon, the Mastodon giganteus, and Mastodon angustidens. So long as this fact remains uncontroverted, we should consider it, taken in connection with other facts, as forming an impassable boundary between the two families.

This tusk is eleven inches long, five and a half in circumference, and two in diameter at the base; being longer by an inch than the cast of a similar one in the collection of the American Philosophical Society, which was taken from the specimen originally described by Dr. Godman, and disinterred by Mr. Archibald Crawford near Newburgh. The direction of our tusk is forward and downward, forming an angle with a horizontal line of about 45°. It has a cavity an inch and a half in diameter at the internal extremity, the thickness of the edge being one-fourth of an inch; this cavity is of a conical form, and two inches deep. The rest of the tusk appears to be solid. The anterior extremity is rounded and about an inch in diameter; on one side it has been worn away to the extent of four inches. The worn surface is smooth at its extremity only, the rest being quite rough; the depth of the external layer is exposed in this abrasion, and exhibits the thickness of an eighth of an inch. Near the posterior or internal extremity are seen a number of circles, to the amount of ten or eleven, extending from the base, to two or three inches forward, and occupying that part which lay in the socket. The surface of the tusk generally exhibits longitudinal striæ, in some of which, cracks begin to appear from desiccation. These striæ are distant from each other from a fourth to an eighth of an inch. The color of the tusk is brown, excepting three inches of its anterior extremity, which are nearly black. At the fissures it is seen to be composed of laminæ about the sixth of an inch in thickness. It is perfectly firm and free from any marked evidence of decomposition."

Dr. Warren mentions more or less fully and figures other Mastodon skeletons found in the United States. Plates 16, 18, 19, are devoted to the Shawangunk head found at Scotchtown, Orange Co., New York, which is particularly described. The size of this head is not exceeded by that of any other hitherto discovered. Its greatest breadth is 31 inches, its vertical elevation 33¼ inches and the length from the ridge of the occipital plane to the extremity of the intermaxillary bones, is 48 inches.

The characteristics of some other species of Mastodon occupy several pages of the work; and the so-called *Tetracaulodon* is recognized as the male of Mastodon giganteus.

The work closes with a dissertation on the food and supposed discovery of hair of the M. giganteus, and on its geological situation and causes of preservation. The author states that of the five skeletons known at this time, three have been found in the fresh water marshes of Orange Co., N. Y., a fourth in an interior morass in New Jersey, and the fifth near the banks of the Missouri, probably in a fresh water deposit. Scattered bones are common from various parts of the country, and even from the far north. They are reported from the surface soil, peat marshes, beds of marl or loam, etc.; but, as Lyell observes, there is yet no satisfactory evidence of their occurrence beneath the proper drift.

The North American Mastodon bones hitherto found appear to belong to the same species, excepting a single tooth, reported from Caroline County, Maryland. Dr. Warren enters into the history of this tooth, discusses the possibility of its being a stray tooth from another continent, and concludes that it is what it purports to be, a true Maryland fossil, closely related to the Mastodon Humboldtius (or M. *angustidens* if the two are one), of South America, if not identical with it.

An Appendix contains various facts of interest, and among them a description of a specimen of the Mastodon angustidens found near Turin, (called the Dusina Mastodon), taken from Sismonda's "Osteografia di un Mastodonte angustidente," published at Turin, in 1851.

ART. XLII.—*Notices of the Rarer Minerals and New Localities in Western North Carolina;* by C. L. HUNTER, M.D.

The Diamond.—The occurrence of the diamond in the United States is now no longer a matter of doubt or uncertainty. On the first announcement a few years since of its discovery in North Carolina, the unexpected information could scarcely be credited by the scientific or intelligent portion of the community, although geological indications favored its existence in the auriferous region of the South. By some, the truth of the newspaper

account was totally denied, and set down as only a *marvellous story*. By others, it was more charitably pronounced a *mistake* in the discoverer, on the ground that diamonds could be found only in South America, or the East Indies. The little gem, however, after a time was produced and exhibited to several scientific individuals, including Prof. Silliman and Prof. Shepard, who pronounced upon its genuineness in accordance with the published statement. This *first* diamond was found, several years since, in Rutherford County, N. C., in the gold washings commonly known as *alluvial deposit*. It weighs about one carat and a half, is of a yellowish color, and presents one of the elongated *adamantoid* shapes. It may be seen figured in both Dana's and Shepard's Mineralogy (3d edition). Early in the spring of the past year (1852) another diamond was found by the writer of this article, in a similar deposit, in Lincoln Co., N. C. It weighs about half a carat, is nearly clear, with a delicate greenish tinge, and presents the same elongated shape as the Rutherford diamond. In the summer also of the past year another diamond was found in Mecklenburg County, N. C. It weighs about three-fourths of a carat, is nearly of the first water, and resembles more nearly than either of the preceding, a brilliant, just elaborated by the artistic skill of the lapidary. It is also reported upon good authority that several small diamonds have been found in the gold washings of Georgia. In every instance, thus far, these little gems have been found in alluvial deposit, or drift, in which may be seen rounded pebbles. The peculiar conglomerate called *cascalho*, strictly speaking, has not been identified; but in several places I have seen a stratum of gravel very compact, and agglutinated as it were by a ferruginous sedimentary *cement*, constituting an aggregate somewhat analogous to this, and perhaps, the repository of the diamond. Be this as it may, the encouraging fact is here presented that in the auriferous region, extending from Mecklenburg Co. to Rutherford Co. in North Carolina, and thence southerly to Hall Co. in Georgia, embracing a section of country at least 75 miles wide by 150 long, the diamond may be sought for by the gold miner, with every prospect of success. It is to be regretted that these recent discoveries had not been made previous to the extensive gold mining operations in Burke, McDowell, Rutherford, Lincoln, and several other Counties. In passing through these Counties we frequently meet with large gravel-piles, extending for miles along the different water-courses. Nearly all of this work was done in a hurried manner, regardless of any other reward than the "yellow dust," scattered, in many places, quite abundantly through the deposit. Such being the case, is it not probable that these deserted gravel-piles may still contain much hidden treasure? And would it not be advisable for all who are now engaged in working *deposit*

mines in the Southern States, or in California, to keep a "sharp look out" for this rare and valuable gem?

Gold.—In noticing this rather abundant metal, it is not intended to tire the reader with a lengthy detail of *golden statistics*, with which our newspapers are almost daily teeming, but simply to present a few curious facts, not generally known, connected with the *history of its discovery* in this country. The first gold found in North Carolina, and probably in the United States, in valuable quantity, (always excepting the mysterious diggings, and unknown discoveries of our aboriginal predecessors,) was in 1799, at the celebrated "Reed Mine," in Cabarrus County, N. C. It was found by a little son of Mr. Reed, about 12 years old, while amusing himself with bow and arrow in shooting for fish on a small stream called "Meadow Creek." The lump of "yellow metal" thus discovered, said to have been of the size of a "small smoothing-iron," was taken home, and retained several years by his father, without knowing its name or value! No one at that early period presumed to think that gold existed in North Carolina, or even in the United States. In 1802, Mr. Reed carried the "lump of strange metal" in his wagon to Fayetteville, an inland town of considerable trade; and while there showed it to a jeweller to ascertain its true name. The jeweller after a slight examination, informed him it was *gold*, and immediately proposed buying it. To this proposal its owner readily acceded, and sold it to the jeweller for the trifling sum of three dollars and fifty cents! This information, although dearly bought, like Franklin's whistle, was highly serviceable to Mr. Reed in leading to future discoveries of great value. In 1803 he associated himself with three others for working the mine, and soon afterwards was richly rewarded by finding the large mass so extensively known, weighing "28 lbs. steelyard weight." In 1804, and a few subsequent years, numerous other masses or "lumps" were found, weighing from one ounce to sixteen pounds. In the "Medical Repository," published in 1804, this early discovery of gold in North Carolina is properly noticed. It is not surprising that these first developments should, for a time, have greatly excited the public mind. Such is a brief history of the *golden discoveries*, and such the origin of the "gold fever" in North Carolina, whose contagious influences have spread, not only to her sister states of Virginia, South Carolina, and Georgia, but to the distant shores of the Pacific, and now threaten to disturb the equanimity of the "Green Mountain boys." Thus both extremes of the Alleghany chain—its southern and northern termini—and the auriferous valleys of the more lofty Rocky Mountains, have been aroused to arms,—not of slaughter, but to new employment of the *pick* and the *shovel*.

Corundum.—A few years since, a straggling bowlder of corundum was found in Buncombe County, N. C. The mass, when broken afforded good specimens of a deep blue color, and highly crystalline lamellated structure. As it was merely an erratic block, it would be well for the mineralogical tourist to search for its original situation in the adjacent mountain ranges whence it was probably *drifted.* During the spring of last year I had the pleasure of discovering a locality of this mineral in Gaston Co., N. C. The specimens thus far obtained, although small, not exceeding 3 or 4 inches in diameter, are interesting from the fact that they were found *in place.* It is quite probable that future exploration will bring to light larger and more valuable specimens. The corundum is here generally associated with an aggregate of *mica* and *quartz.* In some of the specimens, with drusy cavities, may be seen numerous small, flattened, six-sided prisms, arranged singly, and in groups. Some of these crystals, when examined with a glass, are found to be handsomely studded with *specular iron.*

Emery.—At the above corundum locality, may also be obtained emery of good quality associated with *emerylite.* The largest mass procured, about five or six inches in diameter, was exceedingly tough, and difficult of fracture. The gradation in color, from a deep blue corundum to a fine granular emery, nearly black, owing to the mixture of iron, is quite perceptible. This locality is richly worthy of more thorough examination.

Amethyst.—An interesting locality of this mineral is found at Randleman's in Lincoln County. The crystals are remarkable for their size, beauty, and for the splendid groups in which they frequently occur. They are mostly of a smoky, or dark purple color, but occasionally, beautiful pink or rose-colored crystals are found. Perhaps no locality in the southern states has produced so many fine specimens.

Chalcedonic quartz.—An interesting locality of this variety of quartz is found in Rutherford County. The crystals are hollow, nearly pseudomorphs of calcite, and have their interior cavities lined with crystals of chalcedony. Frequently the cavities are filled with water, and hence are known by the name of *water crystals.* This fluid, however, is liable, on exposure, to escape by evaporation through scarcely visible fissures, leaving a yellowish powder, sometimes called *mountain meal.*

Lazulite.—This rare and interesting mineral was first discovered in 1822, by the late Dr. H. S. Hunter, near "Crowder's Mountain," in the southern part of Lincoln County (now Gaston). Specimens were forwarded by him to Prof. Olmsted, then attached to the University of North Carolina, and noticed in his

"Report," (2d part) addressed to the "Board of Agriculture." A few years since, a more abundant locality was discovered about 20 miles northeast of the former near the southern terminus of Clubb's Mountain. The lazulite is here found pervading an *arenaceous* and *micaceous quartz*, appearing to constitute its matrix. Occasionally it is found imbedded in *compact quartz*, and in the triangular cavities of a *reddish kyanite*. It occurs massive, but imperfect crystallizations may be traced on some of the specimens. This locality is exceedingly rich in the variety of its mineral productions, including gold, the most precious, and iron, the most useful of metals. Here, from a gently rising elevation of two or three acres, the mineralogist may obtain the handsome addition to his cabinet of twelve or fifteen different species—some of them rare and quite desirable.

Kyanite.—At the lazulite locality just noticed are also found several varieties of kyanite, constituting, perhaps, two or more species. Some of the specimens are of a handsome bluish green color, with numerous lamellæ diverging in different directions. Sometimes kyanite and talc or pyrophyllite are associated, forming large globular masses. This is the locality alluded to in Shepard's Mineralogy (3d edition) but wrongly printed "Chubb's Mountain." It derives its name from one Gasper Clubb, a submontane resident of the Revolutionary period, whose eccentricity of character and marvellous tales are still remembered by the older inhabitants.

Leopardite.—This is a singular *spotted rock*, found in Mecklenburg County, in the vicinity of the flourishing town of Charlotte. It occurs in large masses, generally presenting a *rhomboidal* or *trapezoidal* shape. It is noticed by Prof. Shepard, under the head of feldspar, as the "leopard stone of Charlotte, N. C." It is regarded by the same authority, as a composition of *compact feldspar* and *quartz*, the spots being produced by the *oxyds of iron* and *manganese*. When broken at right angles to the pervading stripes, this mineral presents the singular spotted appearance which has given origin to the name "leopardite." As this name is quite characteristic of a rather unique rock, I would suggest the propriety of retaining its popular designation. Another locality of this rock has recently been found in Lincoln County. The pervading stripes are, however, generally finer; and when broken *diagonally*, it presents a handsome arborescent appearance. It receives a good polish, and might be used for various ornamental purposes. It may be proper here to state that the block, soon to be contributed by the citizens of Charlotte to the National Monument at Washington City, is of *leopardite;* when finished, it will compare favorably with its numerous associates in that lofty structure.

The preceding notices embrace but a small number of the rarer minerals and undescribed localities in western North Carolina. On a future occasion the subject may be resumed, and additional facts and observations presented sufficiently interesting, it is hoped, to claim the attention of the scientific reader.

ART. XLIII.—*Review of Mr. Blake's Article on the Flow of Elastic Fluids;** by JOEL E. HENDRICKS.

AFTER making some introductory remarks, the writer says:

"If the velocity with which a fluid flows through an orifice be represented by V, the density under which it passes the orifice by D, and the area of the orifice by S, then the product VDS is the measure of the quantity of the fluid discharged in a given time. It is an established law in the dynamics of fluids, that the velocity of the flow is directly as the square root of the pressure, and inversely as the square root of the density. If then the efficient pressure which produces the flow be represented by P, the general law expressed by symbols will be

$$VDS \propto \frac{DS\sqrt{P}}{\sqrt{D}}." \qquad (a)$$

In order to prove that this formula does not properly represent the relation which the author intended it to represent, I will endeavor to show that the formula (a) is only applicable to cases where P is a *momentary* force, and does not apply in the investigation attempted by Mr. Blake; and that, therefore, his determinations are not to be relied upon as necessarily true.

If a momentary force P impinge upon a body b, it will give to that body a velocity V and momentum m. And because every effect is proportionate to its cause, we shall have $m \propto P$. (b)
Also, because the momentum of a body is that body multiplied by its velocity, we have $m = bV$. (c)
Hence by substituting for m in (b) its value as found in (c) we have $bV \propto P$, or

$$V \propto \frac{P}{b}. \qquad (d)$$

And if b represent a column of elastic fluid whose transverse section is S, density D, and velocity V, the expression (d) becomes $V \propto \frac{P}{VDS}$, whence $V^2 \propto \frac{P}{DS}$ and $V \propto \frac{\sqrt{P}}{\sqrt{DS}}$. And when

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* Art. No. 12, Vol. 5, (second series) of the Am. Jour. of Science and Arts.

S is constant $V \propto \frac{\sqrt{P}}{\sqrt{D}}$ and consequently

$$VDS \propto \frac{DS\sqrt{P}}{\sqrt{D}}. \qquad (e)$$

Hence if P be a momentary force which acts upon b for a single instant, then will the formula (a), which is identical with (e), represent correctly the relation between V, D and P, at the orifice.

Again, if a constant accelerating force P, act continually upon a body b during a time t, it will give to that body at the end of the time t a velocity V and momentum m. And because the effect, or momentum m, is proportional to its cause, viz: to the force P multiplied by the time t, therefore $m \propto tP$. (f)
Also because the momentum of a body is equal to the product of the body multiplied by its velocity, we have $m = bV$. (g)
And by substituting for m in (f) its value as found in (g) we have $bV \propto tP$, or $V \propto \frac{tP}{b}$, whence by substituting VDS for b and reducing and supposing S constant, we have $V \propto \frac{\sqrt{tP}}{\sqrt{D}}$, and therefore, by multiplying both sides by DS, we have

$$VDS \propto \frac{SD\sqrt{tP}}{\sqrt{D}}. \qquad (h)$$

Now it is sufficiently obvious that this formula can be identical with (a) only when t is equal to unity. Hence if (a) represent generally the relation between V and P, on the supposition that P is a constant accelerating force, it follows that the velocity V in the formula (h) must have been induced in a unit of time, whatever distance the body may have traversed. Wherefore, in that supposition, V must vary as the distance traversed, or as the length of the discharging vessel when the body is a fluid generated at its farther end. But the space traversed by a body in consequence of the action of a constant accelerating force is as the square of the last acquired velocity. Consequently the last acquired velocity, or V in the formula (h), must vary as the square root of the space traversed; and because if the fluid is generated at one end of the discharging vessel, and discharged at the other, the space it will have to traverse after motion commences and before it attains the velocity V will be the length of the discharging vessel, therefore V in the formula (h) must vary as the square root of the length of the discharging vessel. Now because V cannot, at the same time, vary both as the length and as the square root of the length of the discharging vessel, therefore we cannot restrict t to unity in the formula (h). And conse-

quently P in the formula (a) cannot be a constant accelerating force.

Lastly, if any variable accelerating force P, act continually upon a body b, it will give to that body at the end of the indefinitely small time dt, a velocity dV and momentum dm. And because the effect or momentum is proportional to its cause, viz: to the force P multiplied by the time of its action dt, we have

$$dm \propto dt\mathrm{P}. \qquad \text{(i)}$$

And because the momentum of a body is that body multiplied by its velocity, we have $dm = bd\mathrm{V}$. (k)

By substituting for dm in (i) its value as found in (k), we have $bd\mathrm{V} \propto dt\mathrm{P}$ or $d\mathrm{V} \propto \frac{dt\mathrm{P}}{b}$, and because b is a constant quantity, we have $\mathrm{V} \propto \frac{\int dt\mathrm{P}}{b}$, whence by substituting for b its value VDS, reducing, and regarding S constant, we derive $\mathrm{V} \propto \frac{\sqrt{\int dt\mathrm{P}}}{\sqrt{\mathrm{D}}}$, and consequently

$$\mathrm{VDS} \propto \frac{\mathrm{DS}\sqrt{\int dt\mathrm{P}}}{\sqrt{\mathrm{D}}}. \qquad \text{(l)}$$

Now it is obvious that this formula (l) cannot be identical with (a), unless P be a constant quantity; but in that case the formula (l) will reduce to (h), which it has been shown cannot be identical with (a), therefore the formula (l) cannot be identical with (a). Consequently P in the formula (a) is *necessarily* a momentary force, and therefore the velocity induced thereby must be uniform. But Mr. Blake has shown independently of the formula (a), that in the flow of elastic fluids, the velocity increases as the fluid approaches the orifice, therefore the formula (a) which he employs in his investigation is not applicable to the case he is considering, and consequently his determinations are not necessarily true.

Auburn, Ind., Feb. 14, 1853.

ART. XLIV.—*On a New System of Electro-Magnets;* by M. J. NICKLÈS.*

THE discrepancy pointed out by me between the conclusion of M. Dub, and that of M. Muller and MM. Lenz and Jacobi, as to the influence of the length of the arms of an electro-magnet on the weight carried by them, is only apparent; each of these opinions is based on a special case. The elongation of the arms has in fact some influence, (as M. Dub asserts,) when, (as done

* An addition to the former paper at page 104 of this volume.

by this physicist,) strait electro-magnets are experimented with. On the contrary, it is without effect with horse-shoe or bifurcate magnets, which were employed by Lenz and Jacobi as well as M. Muller. This is shown by the following experiments.

1. *Straight Electro-magnets.*—In my experiments I have used a series of cylinders of iron, of the same diameter and increasing lengths, as follows:

	Millimeters.		Millimeters.
No. 1.	0·050 long.	No. 3.	0·150 long.
No. 2.	0·100 long.	No. 4.	0·200 long.

and so on for 5, 6, etc.

The helix consists of 94 metres of copper wire, a millimeter in section, forming a coil of 754 turns. Cylinder No. 3 was placed in the helix. The weights are given in grammes.

Tang. 11° 20′			Tang. 7° 15′		
Length added.	Weight lifted.	Weight falls.	Length added.	Weight lifted.	Weight falls.
0.	1700 gr.	1750	0.	980 gr.	1000
No. 1.	1900	2000	No. 1.	1100	1150
No. 2.	2000	2150	No. 2.	1210	1250
No. 3.	2150	2240	No. 3.	1260	1300
3+1.	2250	2290	3+1.	1300	1320
3+2.	2290	2300	3+2.	1320	1340
No. 6.	2300		No. 6.	1340	1340–45

The influence of the elongation of the magnetic bar upon the attraction is obvious. Nevertheless it has its limit, from which limit the attraction diminishes as the length of the magnet increases. This is shown in the following table, in which the same method was adopted, but with a more feeble current.

Tang. $\frac{11° 20′}{2}$

Length added.	Weight lifted.	Weight falls.
0.	720	800
No. 1.	845	1000
No. 2.	1000	1170
No. 3.	1050	1140
No. 4.	1150	1220
No. 5.	1050	1200
No. 6.	1050	1210
6+1.	1000	1170
6+2.	950	1000
6+4.	960	990
6+7.	890	940

It is here apparent that the attraction decreases from No. 5. It is also seen that the decrease is more rapid when the bar is made of two or more pieces, instead of being in a single solid piece. This fact, which I have established in various ways, is of great importance in the construction of electro-magnets.

2. *Horse-shoe Magnets.*—As the horse-shoe magnet is only a curved bar with a helix about either extremity, the same results would be expected as with straight bar-magnets, that is, the increase in the length of the arms should exert an influence on the attraction produced by each of the poles *when these poles act singly*. I will mention some of the results which I have obtained, bearing in this direction.

The electro-magnet employed was the system of Mr. Joule,* except that the coarse wire was replaced by 60 metres of wire 1 millimeter in section, making a coil of 324 turns.

Total current, $\frac{\text{tang. } 47° 10'}{2}$		Reduced current, $\frac{\text{tang. } 11°}{2}$	
Iron added to the N. Pole.	Weight borne by the S. Pole.	Iron added to the S. Pole.	Weight borne by the N. Pole.
0 grammes.	180 gr.	0 gr.	175–190 gr.
174	328	174	335
Current tang. $\frac{15° 10'}{2}$			
320	440	320	430

The same results have been obtained with horse-shoe magnets of different forms, and also with the electro-magnet of 3 arms or *trifurcate*, which variety is the special subject of this notice.

Hence the proposition of M. Dub is true, as long as the armature is in contact with *only one* pole of the magnet. But we shall show that this is not so, when both poles act together.

The experiments were made with two horse-shoe magnets of the same section ($0^m{\cdot}010$) and of different lengths; one, 4 decimeters in total length, the other 8. The helices had each 665 turns of a copper wire, 1 millimeter in section; they were free, so that they might easily be removed. I will call the smaller magnet b, and the larger, b'. The intensities of the current were ascertained by means of a rheostat.

These determinations had been already made when the memoir of M. Despretz appeared, on the non-proportionality between the tangents of the deviations and the intensities. But it was of no use to apply to these experiments, or to the following, the formula of M. Despretz, as they have special reference to the properties of electro-magnets, leaving out of view the currents which act in them.

The weights carried by the two opposite poles, were in grammes as follows:

	Tan. 4° 20′	Tan. 7° 40′	Tan. 12° 20′
b	5100 grammes.	7500 gr.	10500 gr.
	5300	7600	10700
	5100		

* Annals of Electricity, v, 187.

	Tan. 4° 20′	Tan. 7° 40′	Tan. 12° 20′
b′	5000 gr.	7289 gr.	10590 gr.
	5200	7610	11000
	5100		

This verifies the results of MM. Lenz and Jacobi, as the length of the arms is without influence on the weights lifted by the magnets.

It should be added that this proposition is true only of horse-shoe magnets furnished with two helices in contrary directions—the condition under which these physicists have experimented. If on the contrary, the two helices are of the same direction, the principle of M. Dub becomes the true one; and it is also the same if the horse-shoe magnet is furnished with only one helix.

As these facts have not yet been presented in a definite formula in any work, I here offer some evidence in their support.

The same electro-magnets were used in these experiments as in the last. I add to the tables of the results, the preceding results, as well as those obtained in determining the weight supported by a single pole of these magnets. The currents are the same as above.

Tan. 4° 20′

Magnets.	2 poles of same name.	2 poles of cont. name.	2 poles one only with a helix.	A single pole.
b	2500 gr.	5100 gr.	1800 gr.	600 gr.
	2300	5200		
b′	3600	5000	510	500
	3500	5200		
		5100		

Tan. 7° 40′

b	4800	7500	4100	2500
	5000	7600		2500
b′	5800	7289	5000	2000
	6000	7610	4800	

Tan. 12° 20′

b	7000	10500	5000	2600
	6900	10700	4850	
b′	9000	10590	4800	3500
	8600	11000	5000	

It follows from these facts:—

1. That in all cases, it is an advantage to use both poles even when only one is under the influence of the current.

2. That a horse-shoe magnet, furnished with a single helix, has more attractive power when its arms are short than when long.

It is on these principles, that the trifurcate electro-magnet of mine is constructed.

I will now add more data to complete my former communication. By its properties this electro-magnet calls to mind the magnets "à points conséquents," its middle pole being much stronger than the two outer.

With this magnet we may obtain a rectilinear motion, which I have in fact found to be true, though in a less degree, with the ordinary magnets. I have stated in my preceding note that the two lateral arms of the new magnet are larger than the middle arm. On placing a cylinder of iron at the origin of the arms perpendicular to their direction, this cylinder rolls with great force towards the centre of the magnet, and returns as often as it is put back to its first position. This movement back and forth, which may be increased in extent, takes place, whatever the position of the apparatus, or inclination of the poles.

This movement appears to deserve some attention, for it enables us to construct electro-magnetic machines in which the magnets act in contact, without producing a shock; for it is well known that with the ordinary machines, the shocks when the magnets touch deteriorate rapidly the power of the machine.

The table below gives the force of attraction exerted by these magnets with currents of different intensities. The armature here used has the size of the central arm; it weighs 1030 grammes; and its rectangular form adapts it well for the experiments, since it may be made to touch by the small or long side, in an axial or equatorial direction, according as it may be desired to act with one, two or three poles; and finally, by using the large surface, the magnetic radiation may be almost entirely intercepted, and we may thus obtain the weights lifted as given in the 4th column.

The total current of the battery was tan. 56° 25′; the reduction observed when the helix was in the circuit, tan. 49° 55′. The different intensities were ascertained by means of a rheostat.

				3 Poles.	
	Current.	Middle pole.	2 Poles.	Armature presented by its edge.	Armature presented by its large surface.
Tan.	49° 55′	3 kil.	80 kil.	130 kil.	180 kil.
	46° 10′	2	68	120	142
	14° 45′		6	15	142
	11° 30′		3	4	142

With an armature of different form these relations are changed; thus a rule of iron, $0^m{\cdot}38$ long, $0^m{\cdot}02$ broad, and $0^m{\cdot}004$ thick, has afforded the ratio of $\frac{1}{3}$ between the weight supported by the middle pole and the three polar surfaces united. Cylindrical armatures of $0^m{\cdot}015$ section, have given analogous results.

Art. XLV.—*Abstract of Meteorological Observations made at Burlington, Vt., in* 1852; by Z. Thompson.

Location. Lat. 44° 29′, Long. 73° 11′, one mile east of Lake Champlain and 256 feet above it.

1852.	THERMOMETER.				BAROMETER.			
Months.	Mean.	Highest.	Lowest.	Range.	Mean.	Highest.	Lowest.	Range.
	°	°	°	°	Inches.	Inches.	Inches.	Inches.
January, . .	14·36	39	−17	56	29·65	30·14	29·05	1·09
February, .	23·19	52	−12	64	29·60	30·46	28·80	1·66
March, . .	28·50	49	− 8	57	29·72	30·36	28·91	1·45
April, . . .	39·86	58	21	37	29·48	29·84	28·77	1·07
May, . . .	56·16	85	32	53	29·67	30·13	29·20	0·93
June, . . .	64·34	97	39	58	29·57	30·02	28·80	1·22
July, . . .	71·08	93	48	45	29·66	30·00	29·13	0·87
August, . .	66·44	90	47	43	29·74	30·02	29·50	0·52
September, .	59·42	90	34	56	29·75	30·10	28·98	1·12
October, . .	47·95	74	27	47	29·72	30·18	29·32	0·86
November, .	35·58	54	15	39	29·62	30·17	29·00	1·17
December, .	30·32	58	− 4	62	29·71	30·39	29·00	1·39
Annual mean,	44·77			114	29·66			1·69

1852.	WINDS.								WEATHER.		SNOW.	WATER.
Months.	N.	N.E.	E.	S. E.	S.	S. W.	W.	N. W	Fair.	Cloudy.	Inches.	Inches.
January, .	12	2	1	1	12	0	1	2	12	19	24	1·03
February, .	5	1	1	2	12	2	3	3	20	9	17	1·69
March, . .	9	0	1	2	12	0	3	4	16	15	22	1·92
April, . .	13	3	1	2	4	1	3	3	17	13	12	1·15
May, . .	5	1	2	4	9	1	2	7	26	5	0	0·71
June, . .	6	1	0	0	14	2	5	2	25	5	0	4·76
July, . .	4	2	1	1	14	1	5	3	28	3	0	4·99
August, .	11	2	0	1	12	2	2	1	23	8	0	1·50
September,	9	0	0	1	13	2	3	2	23	7	0	1·80
October, .	10	1	0	2	12	1	1	4	15	16	0	4·11
November,	10	0	0	1	8	2	7	2	12	18	7	2·90
December,	8	2	0	3	11	1	4	2	14	17	21	2·26
	102	15	7	20	133	15	39	35	231	135	103	28·82

The results contained in the above tables, are derived from three daily observations, made at sunrise, 1 P. M. and 9 P. M.

The warmest day in 1852 was June 15th, which averaged 81½°; and the greatest heat in the shade was 97° on the 16th of June, at 2 P. M. The coldest day was the 20th of January, which averaged 5½° below zero; and the greatest cold was −17° in the evening of January 14th. The mean temperature of the year was about 0·11° colder than the average annual temperature of the preceding fourteen years, and 0·23° warmer than 1851. The mean height of the barometer was 0·05 in. less than in 1851. The range of the thermometer was 0·05° greater, and of the barometer 0·20 in. less than in 1851.

The fall of water, in rain and snow, was 3·25 inches less than the mean annual fall in the preceding fourteen years, and three

inches less than in 1851. The whole amount of water between the 15th of April and the 3d of June, (7 weeks) was only 0·90 in. The mean fall of water in May for the fourteen years preceding 1852, was 3·07 in., and the smallest quantity in May in any one of those years was 1·55 inches, in 1842. The greatest fall of water in any one month, in the fifteen years ending with the year 1852, was 8·11 inches in October, 1850.

The fall of snow in 1852 was 32 inches more than in 1851, and 5 inches less than in 1850. During the year there were 54 days of tolerable sleighing in Burlington and vicinity, thirty-two days less than last year. The broad part of Lake Champlain, opposite Burlington, froze over January 18th, and broke up April 19th, but was not clear of ice through its whole length till the 3d of May, when the Line Boats commenced running. The water of the lake was highest on the 12th of May, being then 1 foot 8 inches below extreme high-water mark, and it was lowest on the 4th of October, being then 7 feet 9 inches below high-water mark—change of level of the lake in the year 6 ft. 1 inch. The extreme change of level has not been known to exceed eight feet.

Robins were seen the 16th, Blue Birds the 17th, and Song Sparrows the 30th of March. Red-winged Blackbirds were seen the 8th, and Barn Swallows the 30th of April. Trailing Arbutus in blossom April 25th, and Liverwort the 29th. In May blossoms opened as follows: the White Elm the 3d, Red Maple the 6th, Gooseberry 13th, Currants 16th, Red Plum 18th, Plums and Cherries 20th, Siberian Crab-apple 23d, Pear 25th, Common Apple 28th. The Summer Yellow Bird appeared the 5th, Baltimore Orioles the 7th, Bobolinks the 10th, and May Beetles the 21st of May.

The Aurora Borealis was observed on 35 different evenings in the course of the year, the most remarkable of which was on the 19th of February.

The temperature of the water of Lake Champlain, at the depth of 125 feet, when the whole surface of the lake was covered with ice, was 34½° on the 5th of April. This was after the rivers flowing into the lake had broken up, and the temperature of the water where the examination was made, had doubtless been reduced by the ice-cold water brought in by the rivers. The general temperature of the water of the lake, after the ice had disappeared and the waters had been thoroughly agitated by the winds, was, on the 23d of April, 36½°.

ART. XLVI.—*Some Account of the Proteus anguinus;* by JNO. C. DALTON, JR., M.D. With a Plate.

IN the Austrian province of Carniola there are a large number of grottoes, the two most remarkable of which are in the immediate vicinity of Adelsberg, a small post-town, about thirty-five miles inland from Trieste. The larger of these, which is the only one usually visited by travellers, and which is justly celebrated for the extent of its passages, and for the elegance and variety of its stalactites, has its entrance on the side of a hill, about fifteen minutes' walk from the village. It is called by the inhabitants the "Grotto of Adelsberg." A small stream flows into its mouth, but disappears after a short distance through one of the numerous chasms which open into the principal passage. The grotto penetrates the hill in a nearly horizontal direction, and can easily be followed for a distance of one to two miles. It has also been explored for nearly twice that distance, but the passage is difficult and dangerous, and its termination has never yet been reached. In the waters of this cavern there are found occasionally a few crabs and fishes, of the same species as those met with outside, and which have been carried in by the stream that enters at its mouth. There is, however, another grotto, situated about a mile farther from the town, called the "Magdalena Grotto," the waters of which contain the curious species of reptile known as the "Proteus anguinus." This is the only place in the vicinity of Adelsberg where the animals are met with; and though they exist also in other parts of Carniola, they are more abundant in the Magdelena Grotto than elsewhere.

Unlike the "Adelsberg Grotto," this cavern receives no stream at its mouth, and penetrates the hill in a steep downward direction, instead of horizontally. After descending, for about fifteen minutes, by an exceedingly rough and irregular passage, partly rocky and partly covered with soft mud, the visitor comes to a pool of still water, varying from 12 to 18 feet in depth, according to the season, beyond which the cavern cannot be explored. It is in this pool that the Proteus is met with. The water apparently communicates with that of the Adelsberg Grotto; as it is always turbid when the latter is so, and vice versâ. Both caverns are, of course, perfectly dark, and can be explored only with torches. The temperature, in the latter part of August, was about 40° to 50° F., and probably does not vary much throughout the year. It is certain, at least, that in winter it is much higher in the interior of the grotto than outside. The Proteus is taken in small hand-nets by the peasants, who watch for the animal as he lies almost motionless near the bottom of the pool, and capture him by a sudden motion of the net. They are not

very abundant, however, and as they can be taken only when the water is perfectly clear, it is seldom that more than 15 or 20 are obtained during the course of a year. The animals should be kept afterward in obscurity, and at a temperature as nearly as possible resembling that of the grotto. It is necessary, also, to change the water in which they are kept regularly every day. With these precautions it is said they may be preserved alive for an indefinite length of time. I have myself kept one of them for several weeks without giving it any food, and at the end of that time it was as active, and nearly as well-conditioned as ever; only the branchiæ had become somewhat smaller. I am told by Mr. Fitzinger, the Superintendent of the Department of Reptiles in the Vienna Zoological Museum, that they have been kept at the Museum for over six years, without any other food than the organic matters usually existing in fresh water.

It is very commonly believed that the Proteus is found only in the Magdalena Grotto. This, however, is an error; as it appears, by a report of Mr. Fitzinger's to the Imperial Academy of Sciences, in Oct. 1850, that there are no less than thirty-one different localities in which the animal is said to have been found since it was first discovered in 1751. Mr. Fitzinger, himself, has seen specimens from eleven different localities. Of these the Magdalena Grotto supplied much the greater number, viz.: 312 out of 479. The reporter states that, in almost every instance, the animals coming from different grottoes, present such striking peculiarities in size, color and shape, that they cannot be considered as belonging to the same species. Accordingly, he rejects the the old name of Proteus Anguinus and adopts instead the generic name "Hypochthon." In this genus he comprises seven different species, as follows:

Hypochthon	Zoisii,	Hypochthon	Laurentii,
"	Schreibersii,	"	xanthostictus,
"	Freyeri,	"	Carraræ.
"	Haidingeri,		

Six of these species are found in various grottoes of Carniola, and the seventh in Dalmatia. Two different species never exist together in the same locality, though sometimes the same species is found in more than one grotto. One of the principal marks of distinction is their size; the maximum length of the different species varying from $9\frac{3}{5}$ to $11\frac{4}{5}$ inches. The tint of the skin is in some species more rosy, in others yellowish. The head is pear-shaped, triangular, or more globular in form. The eyes, also, are more distinctly visible in some species than in others, and vary somewhat as to their situation.

The living specimen from which the drawing for the plate was made (fig. 1) came from the Magdalena Grotto. It belongs to the smallest of the species described by Mr. Fitzinger,

viz.: the H. Laurentii. Specimens of two other species, the H. Haidingeri and H. Freyeri were obtained afterwards at the Vienna Museum for purposes of dissection.

The body of the animal is cylindrical, like that of an eel, with its posterior portion compressed laterally into a kind of vertical membranous fin. There are four extremities, the anterior three-toed, the posterior two-toed. The posterior are considerably smaller and more feeble than the anterior. The first circumstance which strikes the notice of the observer is the almost entire absence of color, and the transparency of the tissues, which allow the cutaneous and subcutaneous vessels, and even the veins and arteries of the extremities to be perceived without difficulty. The heart can be distinctly seen through the skin, at the anterior part of the neck, beating 48 to 50 times per minute. The dark color of the liver, also, shows through the integument very plainly on the under surface of the abdomen. The whole aspect of the animal reminds one very strongly of the fœtal condition of the higher vertebrata, particularly about the extremities, where the transparency of the integuments shows to best advantage. Notwithstanding, however, its delicacy and apparent feebleness, its motions are occasionally very rapid and energetic. They consist of swift undulating movements of the eel-like body and tail. The limbs are nearly useless during rapid progression, and remain almost motionless, applied to the sides of the body. It is only in the slow motions of crawling and turning, that the extremities are used, and then only in a feeble and imperfect manner. The gills, three in number on each side of the neck, are in the form of long tufts; each principal stem being divided into six or seven branches, and these again subdivided into fine twigs. When the Proteus is in rapid motion, they become distended with blood, and of a bright scarlet color, contrasting finely with the light yellowish, indefinite hue of the rest of the body. In a state of rest, however, they are often perfectly pale, like any other part of the surface. The animal occasionally lifts its head above water and takes in air by the mouth or nostrils, which, after remaining sometime in the lungs, is expelled through the branchial fissures in the sides of the neck. Notwithstanding this frequent inspiration of air, however, and the large size of the lungs, the pulmonary respiration is a very imperfect one and altogether secondary to the branchial. It is said that in a moist and cool place, as, e. g., on the floor of the Magdalena Grotto, the Proteus can live many hours, carrying on its respiration by the lungs and through the skin only; but in a warm apartment it expires in a few minutes after being taken out of the water; particularly if the skin is wiped dry, as I have myself ascertained by trying the experiment. Over the whole surface of the skin, from the anterior part of the head nearly to the end of the tail,

there are minute punctiform openings, the orifices of cutaneous follicles, which exude an abundance of transparent colorless mucus. The peritoneal cavity is also filled with a similar exudation.

There are but few peculiarities about the skeleton. The bodies of the vertebræ are articulated to each other by concave surfaces as in the fishes, instead of one of the articulating surfaces being concave and the other convex, as is the general rule among reptiles. The anterior extremities consist of a cartilaginous clavicle and scapula, fused into a single piece, a humerus, radius and ulna, three carpal pieces, and three digits, the two inner ones of which have three phalanges each, and the outer one, which is shorter, only two. The posterior extremities are supported by a simple pelvic ring, resting against the sides of the vertebral column. They are composed of a femur, tibia and fibula, a tarsus composed of three pieces, precisely similar to those of the carpus, and two digits of three phalanges each. All these parts are entirely cartilaginous, or so slightly ossified that it is difficult to be sure whether there is any true bony formation or not. The snout is rather broad and thick. The nostrils open on the under surface of the upper lip, as in *Lepidosiren Paradoxa*. They are continued into a cylindrical, membranous canal, something less than a third of an inch long, situated in the thickness of the lip. There is a long row of fine, sharp, conical teeth in both upper and lower jaw; and in the upper, there is also a second much shorter row, in front of the first. The tongue is erroneously stated by R. Wagner (Comp. Anat. Vertebrata) to be wanting. It is, on the contrary, very easily seen; about one-eighth of an inch long, but consisting only of mucous membrane and adipose tissue. The animal has the vertical stomach and short intestinal canal of the allied genera. The anus is a longitudinal slit, just behind the junction of the posterior extremities with the body. The liver is a long, lobulated organ, wrapped round the stomach and upper part of the intestinal canal, and extending nearly two-thirds the whole length of the abdominal cavity. The heart, enclosed in a pericardium, is composed of a single auricle and ventricle. The arterial trunk arising from the ventricle is partially converted into a double canal by an imperfect longitudinal partition. It sends off, on each side, three branchial arteries, and the returning branchial veins unite immediately below the situation of the heart, to form a single descending aorta. The lungs are simple, elongated, thin, membranous sacs, secured by a fold of peritoneum against the posterior abdominal wall, and somewhat unsymmetrically developed. The left runs down, from its opening into the œsophagus, nearly three-quarters the whole length of the abdominal cavity; the right but little over one-half the length. The blood globules of this animal have been long known to be remarkable on account of their large size.

They can be easily found almost unaltered in the blood vessels, and particularly in those of the gills, even in specimens which have been kept for a long time in spirit. They are of a flattened oval shape, like those of the frog, with a central, white, granular, roundish nucleus, also somewhat flattened. The length of the globules varied, in the specimen examined, from ·0016 to ·0023 inch. The breadth is usually ·0013, and the thickness ·0003. As this last measurement is exactly the diameter of the human blood globule, some estimate may be made of the difference between them. In fig. 4 the blood globules of human blood, of the frog, and of the Proteus (*a*, *b*, and *c*) are magnified in the same proportion, in order to show their relative sizes. The muscular fibres of the body are also very large, and very distinctly striated. Their diameter varies from ·0019 to ·0036 inch. The nerve-fibres were not remarkably large, those from the facial measuring only ·00027 inch in diameter.

The two most interesting peculiarities of the animal, taken in connexion with its subterranean mode of life, are the colorless condition of its skin, and the imperfect development of its visual organs. At first, the eyes seem to be altogether wanting; but on close examination, they may be discovered, in the recent state, as two minute blackish points, situated about the junction of the anterior and middle thirds of the head (fig. 1). When the animal has been preserved in spirits, it is sometimes impossible to distinguish them until the integuments have been removed. They are then found lying immediately beneath the skin, imbedded in a small quantity of adipose tissue (fig. 2). In an individual measuring $8\frac{7}{8}$ inches in length, the eyeball was $\frac{1}{58}$th of an inch in diameter; and the optic nerve, just before joining the globe, $\frac{1}{360}$nd of an inch. Notwithstanding its minute size, however, the eye is sufficiently well developed as to its structure. The sclerotic is covered with brownish spots, mostly hexagonal in shape, and which are more thickly crowded and deeper in shade just at the margin of the cornea, where they form a blackish ring (fig. 3). The crystalline lens is globular, and $\frac{1}{143}$th of an inch in diameter. There were some appearances of a nearly colorless iris, lying behind the cornea, but the parts were so minute that I did not succeed in ascertaining its existence by dissection. The brain is pretty well developed, though less so than in other allied genera; and notwithstanding the imperfect condition of the eyes, the lobes which, in the brain of reptiles, are usually considered as representing the Tubercula Quadrigemina, are of very considerable size. The brain of the Triton cristatus, another naked Amphibian, with large well developed eyes, differs from that of the Proteus simply in being rather larger in comparison with the size of the animal, and in having a somewhat greater proportional development of the hemispherical lobes. The

following are the longitudinal measurements of the brain of a Triton cristatus, $6\frac{1}{3}$ inches long, and that of a Proteus anguinus, $8\frac{7}{8}$ inches long:

	Triton.	Proteus.
Hemispherical lobes,	5 millimetres.	$4\frac{1}{2}$ millimetres.
Tubercula Quadrigemina,	$2\frac{1}{2}$ "	$2\frac{1}{2}$ "
Cerebellum, . .	$1\frac{1}{2}$ "	$1\frac{1}{2}$ "

The two brains could hardly be distinguished from each other, except for the fact that the olfactory nerve in the Proteus runs forward for some distance as a trunk along the inner side of the membranous olfactory canal, while in the Triton it breaks up into branches immediately on leaving the anterior extremity of the brain (fig. 5).

It will be seen that the suppression of the visual organs in these animals is not, by any means, complete. There are, however, other creatures existing in the same localities with the Proteus, in which the eyes are altogether absent. Two species of Crustaceans are found in the caves of Carniola, viz: Palæmon anophthalmus and Titanethes albus, both of which are colorless, diminutive in size (not more than one inch long), and, so far as they have been examined, entirely destitute of eyes. They are supposed by some to be the natural food of the Proteus. I am informed by Mr. Kollar, of the Vienna Zoological Musuem, that a species of spider, entirely blind, has also been discovered in the same caverns.

There is much resemblance, in regard to the condition of the eyes, between the Proteus and Lepidosiren Paradoxa. In the two specimens of Lepidosiren, dissected by Prof. Bischoff, and described by him in a monograph on the subject, the eyes were "hardly a line in diameter," though one of the animals measured over three feet in length. The opening of the eyelids is wanting, also, in Lepidosiren as in Proteus, and the eyeball is completely covered by the integument. So little is known, however, of the mode of life of Lepidosiren, that it is impossible to determine whether the cause of the imperfection be the same in both animals.

Very little is yet known with regard to the mode of reproduction of the Proteus; and, particularly, it is altogether uncertain whether the animals are oviparous or viviparous. Dr. Joseph Hyrtl, Professor of Anatomy at the University of Vienna, states that he has found, at the extremity of the oviduct in the Proteus, a gland which exists elsewhere only in the oviparous species of the naked Amphibia; so that the Proteus is probably also oviparous. But nothing more definite has been discovered. One German observer (von Schreibers) endeavored to ascertain this point by examining specimens of Proteus, taken from their caverns at every season of the year; but, according to Herr Fitzinger, he

only succeeded in finding the ovaries unusually developed in a few instances. H. Fitzinger, himself, has met with the ovaries in a state of active development in only one instance; and up to the present time, according to him, neither ova nor embryos have ever yet been discovered in the oviducts.

The female generative organs consist of two elongated, sacciform ovaries, situated at the posterior part of the abdomen, directly in front of the kidneys. In the specimen measuring $8\frac{7}{8}$ inches total length, in which the generative organs were in a state of quiescence, the right ovary was 0·98 of an inch long,—the left somewhat smaller. The cavity of the organs was lined by a mucous membrane, beneath which were to be seen the whitish, globular, nearly transparent ova, varying in diameter from $\frac{1}{7\,5}$th of an inch downward. The oviducts were a pair of slender and perfectly straight tubes, which, commencing by a wide aperture, at some distance anterior to the ovaries, and running down on the outer and posterior aspect of these organs, opened into the cloaca, just above the orifices of the ureters.

In another specimen, however, obtained at the Vienna Museum, the organs were in a high state of development. The right ovary was 1·75 inches, the left 1·64 inches long, and they contained, together, 66 roundish, opaque ova, of a deep yellow color, and evidently just ready to be discharged. Their average size was a little less than $\frac{1}{7}$th of an inch in diameter. The oviducts were much larger than in the other specimen, and exceedingly contorted, so that they must have attained two or three times their ordinary length. None of the ova, however, had yet left the ovaries, so that nothing new could be learned with regard to the question of viviparity.

ART. XLVII.—*On Ericsson's Hot Air, or Caloric Engine;* by WILLIAM A. NORTON, Professor of Civil Engineering in Yale College.

A SHORT notice of this new engine, containing a description of its construction and working, was published in the last number of the Journal; it is proposed, in the present communication, to enter upon a somewat extended discussion of its theory and performance. The notice referred to describes the stationary test-engine of 60 horse-power, which was set up in the manufactory of Messrs. Hogg & Delamater, New York; in the present inquiry I shall confine my attention chiefly to the enlarged and modified form presented in the engines of the caloric ship Ericsson.

These engines consist of four large double cylinders, "standin a fore-and-aft line; two before and two abaft the shaft of the paddle wheels, and working in pairs upon it." Each cylinder is

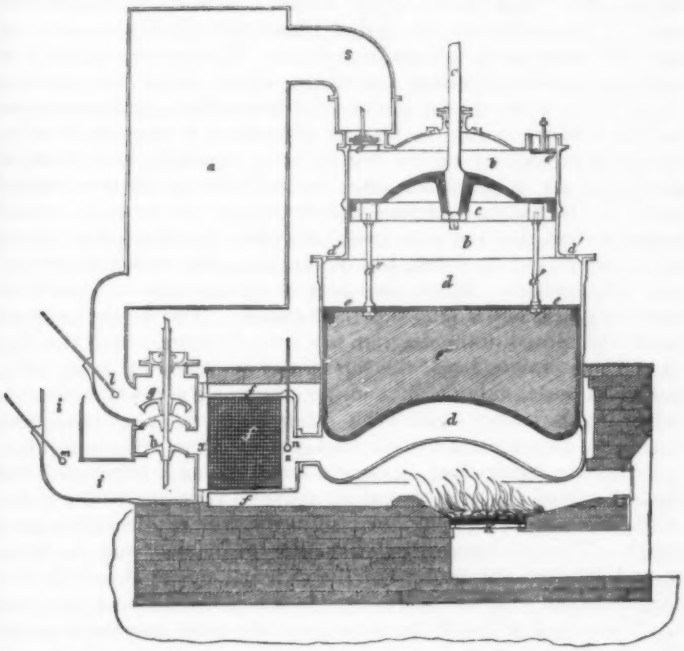
double, the two cylinders being placed one above the other. The lower one, which is the larger of the two, is called the working cylinder, and the other the supply cylinder. The working cylinder is entirely open at the top, and the supply cylinder at the bottom. The pistons which play in the two cylinders are connected by eight strong iron columns, and move up and down together; the length of the stroke is therefore, of necessity, the same for each, viz: 6 feet. For the sake of distinction, the piston in the working cylinder is called the working piston, and the piston in the supply cylinder the supply piston. Underneath each working cylinder is a furnace, which heats the air in this cylinder beneath the piston, and by thus increasing its expansive force, furnishes the motive power of the engine. The expansive force of this heated air drives the working piston up, and with it the supply piston. During the ascent the air above the supply piston which is compressed before it passes through a communicating pipe into the working cylinder, and receiving an accession of heat keeps up the ascensional force. When the pistons have reached their highest point, a valve is opened by the machine, which establishes a free communication between the compressed and heated air under the working piston and the external air; it flows out, and the two connected pistons descend by their own weight. It is to be observed, however, that the mechanical effect of this descending weight is but a compensation for the diminution of mechanical effect produced by the same weight in the ascent, and that the weight of the pistons therefore forms no part of the real motive power of the engine.

Confining our attention to the pair of double cylinders posited on either side of the main shaft, in the vacant space between the working and supply cylinders is placed a horizontal working beam, turning upon a shaft lying between the two double cylinders. One of the supply pistons is connected with one end of this working beam and the other with the other end; by means of links and connecting rods: and so, by the alternate action of the two working pistons, a reciprocating movement is communicated to the working beam. It will be seen therefore, that *one double cylinder*, with the necessary appurtenances, *constitutes a single acting engine*, and that *each contiguous pair of double cylinders*, standing on either side of the main shaft, by the connection of their pistons with the opposite ends of a working beam, *form a double acting engine;* that they accomplish the same end as one double acting steam engine.

The shaft of the paddle wheels of the Ericsson is, accordingly driven by two double acting engines; one before and the other abaft the shaft. Each of these engines has its separate working beam. The power is transferred from each of these working beams to the shaft, (which, it is to be observed, is considerably

elevated,) by means of a connecting rod passing from the nearer end to the crank of the paddle-shaft. The two connecting rods are attached to the same crank-pin; and the relative position of the shaft and working beams is such that each of the connecting rods has a mean deviation of about 45° from the vertical position, and when one rod is passing the dead centre the other is acting upon the shaft with the maximum leverage.

From what has been stated, it will be seen that in studying the essential theory of the new engine, we may confine our attention to one of the double cylinders with its accompanying mechanical arrangements, which taken together form one single acting engine. The essential parts of this engine are shown in the annexed diagram, which is a copy of Ericsson's representa-



tion of the stationary engine.* These are, respectively, the double cylinder, with the pistons and piston rods; the furnace; a large vessel, communicating by pipes with the top of the supply cylinder and the bottom of the working cylinder, called the *Receiver;* and a piece of apparatus placed in the lowermost of these pipes, called the *Regenerator.* The working piston in the engines of the Ericsson, has a diameter of 14 feet, and the supply

* Reduced from a plate in Appleton's Mechanics Magazine for February.

piston a diameter of 11 feet 5 inches. The ratio of the areas of these pistons, and therefore also the ratio of the volumes of the two cylinders is as 3 to 2. The working piston is six feet deep, and concave underneath to fit the cylinder-bottom. The top and bottom, as well as the sides, are of iron, but the space between them is filled with gypsum and charcoal, non-conductors of heat. The packing of the piston is at the top. The working cylinder is of necessity prolonged six feet below the position of the top of the piston when at its lowest point, thus forming a large vessel, called the heater, or heating chamber, into which the air passes from the receiver. By this arrangement the packing at the top of the piston never comes into contact with any portion of the cylinder that is touched by the hot air. The grate of the furnace is five feet below the apex of the dome-shaped cylinder-bottom. Anthracite coal is used, and acts by its radiant heat alone. The supply cylinder is merely a great condensing air-pump, which forces fresh air into the receiver, to be thence transmitted to the heating chamber under the working piston. The supply piston is furnished with thirty-six self-acting valves, which open upwards, and through which the air is admitted into the cylinder in the descending stroke of the piston. During the ascending stroke these valves remain closed, and the compressed air opens another set of valves at the top of the cylinder, and flows along the connecting pipe into the receiver. These two sets of valves may be called respectively, the *outlet* and the *inlet* valves. The valve arrangement represented in the diagram is a little different; both the outlet and inlet valves are at the top of the cylinder. e' is an inlet, and e'' an outlet valve. The air-receivers of the four double cylinders communicate with each other by connecting pipes, and thus form, in connection with the several communicating pipes, one common receiver, of so large a size, that, as it is asserted, the elastic force of the compressed air remains very nearly the same, in the working of the engine. This receiver is provided with a guage. The communications between the receiver and the heater, and between the heater and the external air are closed by two puppet-valves. These valves are shown in the diagram at g and h. The one I will call the *upper*, and the other the *lower* valve. The thermometers at l, n, m, serve to indicate the temperature of the entering and escaping air. When the working piston reaches its lowest point, that is, is nearly in contact with the cylinder bottom, the upper valve is opened by the machine, the compressed air rushes from the receiver, through the regenerator into the space underneath the working piston, and the piston is forced up. At two-thirds of the stroke this valve is closed, and the heated air acts expansively to the end of the stroke. The lower valve is now opened, and the same body of air escapes through it into

the vertical pipe *i*, which communicates with the external air; passing again through the regenerator, on its exit.

The Regenerator is an admirable contrivance of Captain Ericsson's for abstracting the heat, or the greater portion of it, from the escaping air and restoring it again to an equal body of air entering the cylinder, to repeat the work performed by the air which has just escaped; that is, for employing the same amount of heat over and over again. The regenerator consists of a large number of disks of wire-netting, placed side by side, and in a vertical position, in a marginal frame by which they are held very nearly in contact with each other, (see the diagram.) Each disk is six feet high and four feet broad, the wire of which it is made is $\frac{1}{100}$th of an inch in diameter, and there are tens of thousands of minute meshes in the whole extent of the disk. The number of meshes in all the disks, added to the equal number of interstitial spaces between the disks, make up, it is stated, over 20 millions of minute cells through which the air passes and repasses, on its way to and from the working cylinder. In this way it is brought into contact with several thousand square feet of metallic surface, and parts with or imbibes heat almost instantaneously. It is stated that Captain Ericsson estimates the time occupied by a particle of air in traversing the regenerator at about $\frac{1}{300}$th of a second, and that this small interval of time suffices for the transfer of some 400° of heat from the escaping air to the wire, or from the wire to the entering cold air. The clear opening for the passage of the air through the regenerator is about twelve square feet.

We are told that the escape or waste air deposits all of its heat, with the exception of about 30°, in the regenerator, the thermometer at *m* never standing more than 30° higher than that at *l*. Ericsson estimates that in the case of the stationary engine, the amount of fuel wasted in the process of transfer, was only *two ounces* of coal per hour per horse-power, while the amount wasted by the radiation of the heated parts was about nine ounces per hour per horse-power, and the entire consumption about 11 ounces. (See last number of this Journal, p. 286.) But it should be observed that his calculation involves the supposition that the estimated horse-power (60) was realized in the actual working of the engine. We shall be better able to judge of the probability of this, after we have considered the details of the performance of the engines of the Ericsson.

After the engine has got into full operation, and the regenerator has reached its normal condition, there is a great difference between the temperatures of the inner and outer surfaces of the regenerator. We are told that in the case of the regenerator of the stationary engines this difference was never less than 350°. The explanation is found in the fact that the heated air, on its

escape through the regenerator, must undergo a continual diminution of temperature, as it parts with its heat to the successive disks of wire-netting, and on the other hand the entering cold air, on passing through the successive disks, which are of a higher and higher temperature, will tend to lower the temperature of each one of these disks, and at the same time to increase the difference of temperature between the outer and inner surfaces of the regenerator, and thus to compensate for the tendency to equilibrium of temperature produced by the flow of heat from the inner towards the cooler outer surface. For, while it will reduce the temperature of the outer surface, if the regenerator has sufficient thickness, nearly to an equality with the temperature of the external air, the inner surface being exposed towards a highly heated enclosure will be less affected. It is to be observed that the temperature of the external surface of the regenerator cannot at any time be greater than that of the air escaping through the pipe *i*, and that the temperature of the internal surface can never be less than that of the air issuing from this surface, on its passage into the working cylinder, or rather, heating chamber.

The preparation necessary for starting the engine consists in "keeping up a slow fire in the furnaces, for about two hours, until the various parts contained within the brick work shall have become moderately heated, and then charging the receiver with air by means of a hand-pump," until the guage shows a pressure of about eight pounds above that of the external air. The upper valve, *g*, is then opened by a starting bar, and the compressed air flows into the working cylinder, and begins the work of raising the piston.

We are now prepared to inquire into the

THEORY OF THE MOTIVE POWER OF THE ENGINE.

I will first state a few principles which it is important should be kept in view.

1. The expansive force of the heated air under the working piston must be somewhat less than that of the compressed air in the receiver; otherwise the air in the receiver would have no tendency to flow from it into the heating chamber. The difference may not amount to more than a few ounces; it depends upon the obstructions that exist to the free flow of the air and the relative size of the aperture of communication and heating chamber.

2. When the air is flowing from the supply cylinder into the receiver its elastic force must exceed that of the air in the receiver; for the additional reason, beside that just stated, that the valves in the supply-piston would close if no such difference of pressure existed.

In seeking to determine the power of the engine I shall however disregard the inequality of pressure and suppose the expansive force of the air to be the same in the working and supply cylinders as in the receiver, so long as the communications between them are open.

3. Since the two connected pistons are of unequal size, and the elastic force of the air pressing upon them the same or nearly the same, the entire upward pressure exceeds the downward pressure, and the two pistons are urged up with a force equal to the difference of these pressures. This statement is here made with respect to the actual pressures subsisting when the communications are open. We shall see hereafter that it might also be made in regard to the mean effective pressures throughout the stroke.

4. In the engines of the Ericsson the cut off is introduced at the $\frac{2}{3}$ stroke, and therefore the space underneath the working piston into which the air is admitted from the receiver, before the cut off valve is closed, is equal in volume to the interior of the supply cylinder. It will soon be seen that this is in accordance with a general principle, the adoption of which is essential to the most efficient operation of the present form of engine.

5. When the engine has reached its permanent working state the quantity of air admitted into the working cylinder each upward stroke of the piston, cannot exceed the quantity forced into the receiver, from the supply cylinder, during the same interval. In fact it must be less, by reason of the waste from *leakage* and *clearance*.

Now it will be perceived that if this quantity of air, after being admitted into the working cylinder, as just supposed, retained the same temperature, its elastic force would be the same as that of the external air (15 lbs. say, per square inch); since the same quantity originally filled the supply cylinder, at this pressure. But if we suppose its temperature to be elevated 480°, or thereabouts, by the heat derived from the regenerator and the heating chamber, its elastic force would be doubled, or amount to 30 lbs. per square inch. To realize this supposition the compressed air in the receiver must therefore have an expansive force of over 30 lbs., or 15 lbs. above the atmospheric pressure. If the working temperature in the lower cylinder were 384° above the temperature of the external air instead of 480°, then the pressure in that cylinder, and of necessity therefore in the receiver, would be 12 lbs. above the atmospheric pressure, (i. e. $\frac{3}{4}$ s $\frac{4}{5}$ths of 15 lbs.) It will be seen then that the working pressure in the receiver and the working temperature in the principal cylinder are necessarily connected together—that the one determines the other.

It is here supposed that there is no leakage or clearance, but the fact is otherwise; and therefore the quantity of air admitted into the working cylinder, each ascending stroke, is less than

that which is expelled from the supply cylinder into the receiver. If we suppose the pressure in receiver to be 8 lbs. above the atmospheric pressure, and that the leakage and clearance, at this pressure amounts to $\frac{1}{4}$, then $\frac{3}{4}$ of the air furnished by the supply cylinder will enter the working cylinder, and its elastic force, for the $\frac{3}{4}$ stroke, would be reduced to $11\frac{1}{4}$ lbs. ($\frac{3}{4}$ of 15 lbs.), by the expansion, if the temperature remained unchanged, but the 480° of additional heat will augment this to $22\frac{1}{2}$ lbs., or 15 lbs. $+ 7\frac{1}{2}$ lbs. Now 8 lbs. above the atmosphere, is the actual working pressure of the engines, we may conclude therefore, that if the working temperature is 480° above the atmospheric temperature or a little less, the waste from leakage and clearance, during the double stroke, must amount to nearly $\frac{1}{4}$. The actual working temperature is undoubtedly less than this, but how much I have not been able to ascertain with certainty. The actual leakage is therefore less than $\frac{1}{4}$, but its exact amount cannot at present be determined. According to the newspaper accounts the working temperature, on the trial trip, was about 450°, or 418° above the temperature of the air (taken at 32°). This would make the waste, from leakage and clearance, about $\frac{1}{3}$. It undoubtedly lies between $\frac{1}{4}$ and $\frac{1}{3}$.

Working at a given temperature, and with a given cut off, the leakage will determine the working pressure. To show this, suppose the elevation of temperature to be 480°, and the leakage $\frac{1}{4}$ at a pressure of 8 lbs., shown by the receiver-guage; then at 12 lbs. pressure the leakage, if we disregard the clearance which is comparatively small, would be $\frac{3}{8}$ths, and the elastic force of the air in the working cylinder would be reduced from $7\frac{1}{2}$ lbs. to $3\frac{3}{4}$ lbs. If the communications remained the same, so great a difference of pressure between the receiver and cylinder could not be realized; an additional quantity of air would flow out of the receiver, and this would go on for each successive stroke until the pressure in the receiver was reduced to 8 lbs., or thereabouts, when the pressure in the cylinder would be $7\frac{1}{2}$ lbs., and the engine would be nearly in its permanent working condition.

From this cause, (viz., the leakage,) mainly, as it would seem, the expected pressure of 12 lbs. has not been obtained in the working of the engines of the Ericsson. This is in fact the reason assigned by the builders of the engines, for the fact that no higher pressure than 8 lbs. has yet been realized.

There is another mode of presenting the theory of the motive power of the caloric engine. Suppose that the constant pressure in the receiver is 15 lbs. + 15 lbs. On this supposition air will begin to pass from the supply cylinder into the receiver, at the end of the $\frac{1}{2}$ stroke, or thereabouts, and will continue to flow to the end of the stroke, at a pressure a little above this. At the end of the $\frac{1}{2}$ stroke of the supply piston the body of air which

originally filled the supply cylinder at 15 lbs. pressure, will occupy one-half the space at 30 lbs. pressure. Now, while the communication between the receiver and the working cylinder continues open, that is during the $\frac{2}{3}$ stroke, if we disregard the leakage, &c., the same quantity of air, at the same pressure of 30 lbs., will flow from the former to the latter. It is capable of filling a space equal to one-half of the supply cylinder, or what amounts to the same, one-third of the working cylinder, at the same temperature, without any change of pressure; therefore in expanding to fill two-thirds of the working cylinder its expansive force will be reduced to 15 lbs. To compensate for this it is only necessary that its temperature, as fast as it flows in, should be elevated 480°, when its expansive force will be retained at 30 lbs.

A similar explanation may be given for any other supposed pressure and temperature, and the question of the leakage may be considered from this point of view.

It has been stated that the cut off, whatever may be the relative size of the two cylinders, should be so adjusted that the portion of the working cylinder into which the air is admitted while the valve remains open, will be equal in volume to the whole supply cylinder. To show this, we will at first leave the leakage out of view, and denote the fractional part of the stroke answering to the cut off supposed, (in the present engines $\frac{2}{3}$) by a, and a larger fraction of the stroke, answering to a different cut off, by b. Let b be n times greater than a. Now, if we conceive the fractional cut-off-stroke to be less than a, the actual working pressure remaining the same, the mean effective pressure, for the whole stroke, will be less than when a is used. If, on the other hand, it be made greater, (as $b=na$), the body of air which originally filled the supply cylinder, at 15 lbs. pressure and 32° temperature, on entering the working cylinder, will expand n times, and its working force will be $\frac{15}{n}\times 2$ (supposing working temperature to be $480°+32°$); whereas, for the cut off a the force will be 15×2, and in the subsequent expansion from a to b, the mean force throughout the fractional stroke b will be greater than $\frac{15\times 2}{n}$, since this will be the actual force after the expansion to b.

The same will be true if we take the leakage into account; for suppose the leakage to reduce the pressure of the air that fills a, before it is heated, to $\frac{15}{m}$, then when heated 480° the pressure becomes $\frac{15}{m}\times 2$, which we will put equal to k. Now, if we suppose, as before, the cut off to be increased from a to b, the force

k will be reduced to $\frac{k}{n}$; but the mean effective pressure for the same fractional stroke b, when the cut off a is used, will be greater than this, and the actual pressure after the expansion to b, will be $\frac{k}{n}$. So that the constant pressure for the b cut off is equal to the pressure for the a cut off reduced by the expansion to b.

It may be well to inquire, in this connection, into the proper relative size to be given to the supply and working cylinders to obtain the greatest amount of motive power from the engine. Let A = area of supply piston, and x = ratio of working to supply piston; then, by what we have seen, the portion of the stroke during which the air is flowing into the working cylinder, and acting with its full constant pressure is equal to $\frac{1}{x}$. Calling this pressure per square inch, P, the following proportion gives us the mean effective pressure (p) on working piston, for the whole stroke, viz., x : hyp. log. $x+1$ :: P : $p = \frac{\text{P log. } x+\text{P}}{x}$. The mean effective upward pressure upon the whole piston will therefore be expressed by $\frac{\text{P log. } x+\text{P}}{x} \times \text{A}x$, or $\text{P.A log. } x+\text{P.A}$. The downward pressure on the working piston = 15 lbs. $\times \text{A}x$, and hence the resulting effective pressure = $\text{P.A log. } x+\text{P.A} - 15\text{A}x$. With the aid of the differential calculus, we find this expression to be a maximum when $x = \frac{\text{P}}{15}$, $\left(\text{more accurately } \frac{\text{P}}{14{\cdot}7}\right)$; from which it appears that the engines will have the greatest possible power, at any given working pressure, when the cut off, taken inversely, and the ratio of the volumes of the two cylinders, are each equal to the working pressure per square inch, divided by the atmospheric pressure (15 lbs). Accordingly the ratio of the bulks of the cylinders ought to vary with the working pressure used. When this pressure is 8 lbs. above the pressure of the atmosphere, the cubical content of the supply cylinder ought to be $\frac{6\,4\,8}{1\,0\,0\,0}$ of that of the working cylinder, and the portion of the stroke from the commencement at which the air is cut off, the same. The actual ratio of the cubical contents of the cylinders of the engines of the Ericsson is $\frac{6\,6\,5}{1\,0\,0\,0}$, ($\frac{6\,6}{1\,0\,0}$ nearly), and the fraction of the stroke at which the air is cut off is said to be about $\frac{6\,3}{1\,0\,0}$.

If a pressure of 12 lbs. instead of 8 lbs. were used, the same ratio ought to be $\frac{5\,5}{1\,0\,0}$. This would make the radius of the working piston 15·4 feet. It was Ericsson's original design that it should be 16 feet.

Let us see now how the *power of the engines* of the caloric ship is to be determined. The actual pressures upon the two

pistons are the same, or nearly the same, while the communications are open; the pressure on the top of the supply piston begins at 15 lbs., becomes 8 lbs. + 15 lbs. at the $\frac{2}{3}$ stroke from the end (more accurately $\frac{8.5}{15.5}$), and continues the same to the end of the stroke. The air is shut off from the working cylinder at the same fractional part of the stroke, and acts expansively to the end of the stroke. The mean effective pressure per square inch, for the whole stroke, is then the same upon both pistons. It may be found in the usual manner, by the use of hyperbolic logarithms. Multiply this, diminished by 15 lbs., into the difference between the areas of the two pistons, expressed in square inches, and again into the velocity of the piston per minute, and divide the product by 33,000, and the result will be the *horse-power* of one of the engines.

But it is to be observed that the result thus obtained will be somewhat too large, for the following reasons. 1. The actual pressure in the supply cylinder is greater than the pressure in the receiver (8 lbs.), and the actual pressure in the working cylinder is less than this. 2. During the $\frac{1}{3}$ stroke from the commencement, the outlet valves at the top of the supply cylinder remain closed, and consequently the expansive force of the air in the receiver must be somewhat reduced by the flow of air from it into the working cylinder. 3. After the cut off valve is closed, the elastic pressure of the air in the working cylinder during the remaining $\frac{1}{3}$ stroke, must be diminished somewhat by leakage. The effect of this leakage has not hitherto been taken into account.

PERFORMANCE.

There have been two trial trips of the Ericsson, in the New York harbor and bay, and the ship has subsequently made a successful trip to Alexandria and back. On the first occasion, only the inventor, owners and crew were present. The performance on the occasion of the second trip (Jan. 11th, 1853) was witnessed by the members of the New York press, and a few other gentlemen, present by invitation. The results of the trip have been published in all the New York papers, but the different accounts disagree very materially on most of the important points. By personal inquiry and by consulting the most reliable accounts I have endeavored to come as near to the truth as possible. The following are the principal results:

No. of revolutions of wheels per minute, (according to Ericsson),	9¼
Same, (according to other most reliable authorities),	9
Speed through the water, (according to Ericsson),	8½ miles.
" " " " (according to other authorities),	7 "
Working pressure in receiver, per square inch,	8 lbs.
Consumption of anthracite coal in 24 hours,	6 tons.

The two estimates of the speed through the water are quite different, but the number of revolutions of the paddle wheels, as stated by different authorities, lies between 9 and 9¼. The number of revolutions, about which there is but little disagreement, will enable us to obtain by calculation a pretty close approximation to the speed. For this purpose we have the following data. Diameter of the wheels from centre of pressure to centre of pressure, 30¾ feet; paddles 32 in number, on each wheel, and 10½ feet long by 16 inches deep; dip of the wheels 44 inches. The following quantities were obtained by calculation, viz: number of paddles in water, on each wheel, 7; immersed paddle surface on both wheels, 196 square feet; area of midship section, at 17 feet draft, 520 square feet; ratio of immersed paddle surface to area of midship section, 1 to 2·653; same for steamship Arctic, 1 to 1·662 (see Journal of Franklin Institute for Jan., 1853, No. 1, p. 33); slip of wheels of Arctic, 19·32 per cent. From which we find the slip of the wheels of the Ericsson, on the trial trip, to have been 24·4 per cent. The distance passed over by the centre of pressure of wheels was 9·88 miles per hour. Hence, allowing for the slip, the speed of the ship was 7·47 miles per hour. If we allow for the less oblique action of the paddles in the case of the Ericsson than in that of the Arctic, we find the speed to have been 7·57 miles per hour (the slip of the wheels being reduced to about 23·4 from this cause).

There is some little uncertainty with regard to the area of the midship section. Although I have not succeeded in obtaining the data necessary for an exact calculation of this element, the information furnished me in reference to the model of the Ericsson as compared with that of the steamers of the Collins line, has enabled me to approximate very nearly to a correct result. The rule by which the calculation was made has been tested by trying it upon a large number of ships. It gives results, in almost every instance, a little too small; thus for the Arctic, the result is 662, and the true area is 685. The greater "dead-rise" of the Ericsson may diminish the area, as compared with the Arctic, some 30 square feet; which would make it about 510 square feet. It in all probability, lies between 520 and 500.

If we take it at 500, the slip of the wheels comes out 23 per cent., and the speed of the ship 7·61* miles. In view of all that has now been stated, we may conclude that *the average speed of the Ericsson through the water, on the trial trip, could not have exceeded 7¾ statute miles per hour;* and was most probably about 7½ miles.

Horse-power of the Ericsson's Engines, developed on the trial trip. Working pressure of air, 8 lbs. + 15 lbs. Supposing the

* If we take the number of revolutions of the paddle wheels at 9¼, the speed comes out 7·88 miles.

cut off to be at $\frac{1}{2}\frac{5}{3}$ (=·652) of the stroke, then the mean effective pressure, in each cylinder, would be 6·4 lbs.+15 lbs.; and the horse-power of both engines, calculated by the rule given on page 403, would be 311. If we take the cut off $\frac{6}{1}\frac{3}{6}$, as it is stated to be in some accounts, then the mean effective pressure in the working cylinder we find to be 6·04 lbs.+15 lbs., while that in the supply cylinder remains at 6·4+15. With these data the result obtained for the horse-power is 259.

For a mean effective pressure, in each cylinder, equal to 6 lbs. the result is 292; and for 6½ lbs., it is 316.

The power developed by the engines on the trial trip, was undoubtedly less than the determination above obtained (311), for the reasons mentioned on page 403; we may safely conclude that *it could not have exceeded* 300 *horses-power.* It was probably less. This is but one-half of the full power of the engines, according to Captain Ericsson's estimate. This estimate supposes a working pressure of 12 lbs. to be employed, whereas, by reason of leakage, &c., but 8 lbs. could be obtained. In fact, making the calculation on the supposition of a working pressure of 12 lbs., and taking the cut off at ⅔ stroke, neglecting also the clearance, which is not known, I find the horse-power of the two engines to be 640. The allowance for clearance, and other causes of reduction which have been indicated (see p. 403), may well reduce this determination to 600.

The power, but for practical difficulties, may be indefinitely increased, by enlarging both cylinders, keeping their relative size the same.

It is stated that Captain Ericsson has fixed upon 12 lbs. as the highest limit likely to be practically reached in the working of caloric engines. This must be regarded as an indication either that it is not expected the leakage will be entirely stopped, or that it is supposed that it will not be regarded as safe and economical, to work at the high temperature of 500°, and upwards, necessary to double the expansive force of the air.

Consumption of Fuel, on trial trip, 6 tons of anthracite coal per day, or 560 lbs. per hour. This amounts to 1·87 lbs. per horse-power per hour. If the full power of the engines (600) were to be developed, the expenditure would be 0·93 lbs. per horse-power per hour. On the other hand, if we allow that the excess of pressure in the receiver over that in the working cylinder, on the trial trip, was $\frac{3}{1\,0}$ of a pound per square inch, and the excess of pressure in the supply cylinder over that in the receiver the same, we find that, with a cut off at ⅔, the horse-power developed could not have been more than 248. The expenditure of fuel, answering to this determination, would be 2·26 lbs. per horse-power per hour.

COMPARISON WITH THE STEAM ENGINE.

1. *Comparative Consumption of Fuel.*

This is presented in the following table.

TABLE I.

Name of ship.	Press. of steam or air.	Horse-power.	Lbs. of bit. coal.	Equiv. lbs. of anth. coal.
	lbs.			lbs.
Ericsson, ...	6·4	300	. .	1·87
"	6·3 and 6·9	248	. .	2·26
"	10·3	600*	. .	0·93
Humboldt, ...	22·1	2397	2·71	2·23 to 2·37
Franklin, ...	20·3	1732	3·55	2·48
Washington, ...	18·3	992	3·38	2·37
Hermann, ...	17·4	944	3·42	2·39
Ohio, ...	23·4	1732	. .	2·59
Georgia, ...	23·4	1732	. .	2·59
Falcon, ...	22·5	534	3·81	2·66
Fulton, (the third,)	31·8	823	. .	2·77
South America, ..	31·8	1168	. .	2·60

The second column shows the mean effective pressure of the steam, or air, per square inch, on the piston; the third the real horse-power actually developed by the engines of each ship; the fourth the number of pounds of bituminous coal, per horse-power per hour, consumed; the fifth the equivalent amount of anthracite of coal, i. e., the number of pounds that would do the same work. These several quantities answer to the average performance of the engines, except in the case of the South America, (a Hudson river boat,) in which they show the maximum performance. The data for the calculations were obtained for the most part, from Stuart's "Naval and Mail Steamers of the United States." The mean effective pressure of the steam, for the whole stroke, has, in each instance been diminished 2 lbs. to allow for the reaction of the imperfectly condensed steam on the other side of the piston. The reductions from the fourth to the fifth column were effected, except in the case of the Humboldt, by multiplying by $\frac{7}{8}$ (nearly in accordance with the results of certain experiments and investigations made by Charles B. Stuart, Esq., Chief Engineer of the U. S. Navy. (See work just quoted, pp. 183 and 186.)

The following results were obtained by diminishing the average boiler pressure 2 lbs., which is about the usual excess of the boiler over the cylinder pressure.

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* This is Capt. Ericsson's estimate of the power of the engines at a pressure of 12 lbs. in the receiver.

TABLE II.

Name of ship.	Effec. press. of steam or air.	Horse-power.	Lbs. of bit. coal.	Equiv. lbs. of anth.
	lbs.		lbs.	lbs.
Ericsson, ...	6·4	300	. .	1·87
"	6·3 to 6·9	248	. .	2·26
"	10·3	600	. .	0·93
Humboldt, ...	20·5	2235	2·91	2·31 to 2·54
Franklin, ...	18·8	1607	3·82	2·67
Washington, ...	16·9	911	3·66	2·56
Hermann, ...	16·0	866	3·72	2·60
Ohio, ...	21·7	1606	. .	2·80
Georgia, ...	21·7	1606	. .	2·80
Falcon, ...	20·8	494	4·12	2·88
Mississippi, ...	14·0	539	5·26	3·68
Arctic, ...	19·0	2290	. .	3·50
Fulton, (the third,)	30·1	776	. .	2·93
South America, ..	30·1	1104	. .	2·75

In the two cases of the Arctic and Mississippi, the mean effective cylinder pressure was obtained by an indicator. The results, given for the other steam ships would doubtless be nearer the exact truth if an additional allowance of from 1 lb. to 2 lbs. were made for the greater reaction of the partially condensed steam in the cylinder than in the condenser. If an allowance of 2 lbs. be made, on this account, we obtain the following result.

TABLE III.

Name of ship.	Effec. press. of steam.	Horse-power.	Llbs. of bit. coal.	Equiv. lbs. of anth.
	lbs.		lbs.	lbs.
Humboldt, ...	18·5	2017	3·22	2·65 to 2·82
Franklin, ...	16·8	1436	4·27	2·99
Washington, ...	15	862	4·15	2·90
Hermann, ...	14	758	4·22	2·97
Ohio, ...	19·7	1458	. .	3·08
Georgia, ...	19·7	1458	. .	3·08
Falcon, ...	18·8	446	4·56	3·18
Mississippi, ...	14·0	539	5·26	3·68
Arctic, ...	19	2290	. .	3·50
Fulton, ...	28·1	727	. .	3·13
South America, ..	28·1	1036	. .	2·94

The average consumption of anthracite coal by the several steam ships named in the table is 3·11 lbs. per horse-power per hour. Dividing by 1·87 and 2·26, we obtain the quotient 1·66 and 1·38. From which it would appear that the advantage is in favor of the caloric engine, in the proportion of 5 to 8·3, for the one estimate of the horse-power developed on the trial trip, and of 5 to 6·9 for the other estimate. If Ericsson's estimate of the power of the engines of the caloric ship should hereafter be realized, then the gain in the expenditure of fuel, would be in the ratio of 1 to 3·39. But we shall soon see, in another connection, that the comparison ought rather to be made with the numbers given in Table II. If this be done, (omitting the results obtained for the Mississippi and the Arctic, which correspond more nearly to the supposition made in Table III), we find the advantage in favor of the Ericsson, in so far as it has hitherto shown its capa-

bilities to be in the proportion of 5 to 7·3, or 5 to 6; that is, to be in all probability, in a ratio lying between these two limits. If we make a comparison with the Washington and the Humboldt, the highest admissible ratio is found to be $\frac{6{\cdot}8}{5}$, and the lowest $\frac{5{\cdot}7}{5}$.

We conclude therefore that the saving of fuel hitherto effected in comparison with the condensing steam engine, in its most economical operation, is not more than $\frac{2}{7}$,* and may be as low as $\frac{1}{6}$.

At the same time it is to be observed that if the supposed inherent capabilities of the new engine should be realized, the saving effected might amount to no less than 70 per cent.

2. *Weight of the Engine.*

Calculation of the Weight of the Engines of the Ericsson.—Weight of hull, from 1200 to 1300 tons, as deduced from the weight of the hull of the Arctic; displacement, at 17 feet draft, 2200 tons, as calculated by the builders of the ship; ballast, 200 tons of pig iron; weight of masts and rigging, coal, &c., 100 tons, at the outside: hence weight of the engines and paddle wheels, $= 2200 - 1300 - 200 - 100 = 600$ tons, or $2200 - 1200 - 200 - 100 = 700$ tons.

I find that the same rule for the calculation of the displacement, from the length, breadth, and depth, which gives the displacement of the Arctic correctly, and a near approximation to that of American steamships generally, makes that of the Ericsson at 17 feet draft, about 2600 tons, which is 400 tons above the estimate made by the builders of the ship; a fact which is to be attributed, doubtless, to the peculiar model of the ship.

Comparison with weight of Steam Engine.

	Horse-power.	Weight.	Rates of weight to horse-power.
Mississippi, ...	539 (developed)†	494 tons.	0·91
Missouri, ...	600 (estimated)	500	0·80
Saranac, ...	605 "	367	0·61
Michigan, ...	334 "	160	0·48
Niagara, ...	1440 (developed)	150	0·10
Ericsson,‡	300 "	600	2·20
"	300 "	700	2·33
"	600 (estimated)	600	1·00
"	600 "	700	1·16

* If the comparison be made with the Ohio and Georgia, the saving may be nearly $\frac{5}{8}$.

† This shows the horse-power of the Mississippi developed in its average performance. There can be no doubt that its full power is over 600; and therefore that the ratio of the weight to the horse-power is as low as 0·82. Besides, the weight of "wheels, bunkers, tools, duplicate pieces of engine, stores of the engine department, &c." is set down at 288 tons, which is more than 100 tons above what would be deemed a sufficient allowance. Reducing the total weight to 400 tons, we have the ratio 0·67.

‡ If we take the lowest determination of the horse-power of the Ericsson, viz., 248, the ratio of the weight to the horse-power comes out 2·82.

The numbers given in the second column include the weight of the boilers, water in boilers, coal bunkers, and all appurtenances, together with the weight of the paddle wheels.

It appears from this comparison that, in proportion to the actual horse-power, the weight of the Ericsson's engines is about three times as great as the ordinary weight of the engines of sea steamers; and in proportion to the estimated power, more than 30 per cent. greater.

3. *Space occupied by the Engines.*

This point has been attentively considered by a correspondent of the Journal of the Franklin Institute (see the second February number of the Journal, p. 128), who shows that here also the advantage is on the side of the steam engine;—the economy of space being nearly twice as great.

4. *Friction and other Resistances.*

We may obtain an estimate of the comparative resistance, in the two forms of engine, to be overcome by the moving power, by reducing the power of several steam engines to the speed and immersed midship section of the Ericsson on the occasion of the trial trip; that is, calculate what reduced power they would have if they were just capable of propelling with a speed of 7 or $7\frac{1}{2}$ miles per hour, the ships in which they are placed, if the area of the immersed midship section were the same as that of the Ericsson at 17 feet draft, i. e. 520 square feet. This may be effected by observing that the horse-power will vary nearly as the cube of the velocity multiplied into the area of the transverse midship section. This is quite near the truth, if we suppose the diminution of power to be accomplished by reducing the area of the piston, and other parts of the engine proportionally; the pressure of the steam, cut off, and all other circumstances remaining the same. The following table contains the results of a few calculations made by the rule just stated.

	Horse-power.	Speed.	Area of mid. sec.	REDUCED HORSE-POWER.	
				Speed of 7 miles.	Speed of $7\frac{1}{2}$ miles.
		miles.	sq. ft.		
Mississippi,	539	8·4	684	224	276
Arctic,	2290	13·4	685	215	264
Washington,	911	11·0	608	202	247
Fulton,	776	13·3	281	210	259
S. America,	1104	18 (assumed.)	132	257	316

These determinations, although they differ considerably among themselves, as was to be expected, from the variety of size and model of the hulls of the several vessels selected, as well as of construction and operation of the different engines, and are not to be regarded as very exact, still serve to show that no just claim

can be set up of superiority on the part of the hot air engine over the steam engine, on the ground that the resistance incident to the movement of the engine is decidedly less. Also, on observing that the horses-power given in Table II. were used in making the calculations for the Washington, Fulton and S. America, it will be seen that the statement just made is still true if we include among the several resistances in play in the steam engine, the excess of the reaction of the partially condensed steam in the cylinder over that of the same in the condenser. We may hence conclude that we were justified in making the statement that the comparative consumption of fuel by the two engines, in producing the same useful effect, is to be ascertained by taking the determinations of expenditure given in the last column of Table II, rather than the larger values to be found in Table III.

5. Adaptation to the production of high velocities.

At double the speed of the Ericsson on the trial trip, that is at 14 to 15 miles per hour, the horse-power would be about eight times greater, or about 2400; and the quantity of coal consumed, deduced from the present capabilities of the engine, would be eight times greater, or 48 tons per day. This supposes the draft to remain the same, whereas it will be materially increased by the necessary augmentation of the weight of the engines. In fact the weight of the engines at the speed supposed would be about three times as great as their present weight. At her present draft, (viz., 17 feet,) an additional weight of 200 tons would sink the hull of the Ericsson one foot. Taking the lowest estimate of the weight of the present engines (600 tons), the necessary addition of weight would not be less than 1200 tons; which would sink the hull nearly 6 feet, or increase the draft to about 23 feet, that is, make the draft after the 200 tons ballast is removed, 22 feet; which is from 1 to 2 feet deeper than the load-line. The midship section would thereby be enlarged to 720 square feet, and therefore the power necessary for the production of the double velocity augmented in the proportion of 520 to 720. If this be done, we find the required horse-power to be 3320. The corresponding consumption of coal would be 66 tons per day. Now even at 50 tons per day the stock of coal required for a transatlantic voyage of 12 days duration, would not be less than 600 tons; which would produce an additional depression of the hull, of nearly 3 feet, or sink it some 5 feet deeper than the load-line. If it should be maintained that the weight of the engines would not be more than doubled, the depression produced by the engines and the necessary supply of coal would still be below the load-line. Again, if it should be conjectured that the consumption of coal will not be augmented, in the case of the caloric engine, in the same proportion as the real horse-

power, to show that this supposition is erroneous it is only necessary to state that, as a matter of fact, the amount of coal consumed for each horse-power by the engines of the Ericsson, is even greater than that consumed by the stationary caloric engine. Ericsson gives 60 as the horse-power of the stationary engine, and 0·6 lbs. per horse-power per hour as its consumption of fuel, and 600 and 0·9 lbs. as the corresponding quantities in the case of the Ericsson's engines.

Let us now see what will be the result in case the estimated capabilities of the caloric engine should be realized. If the horse-power should be increased from 300 to 600, the speed of the ship would be increased nearly in the proportion of the $\sqrt[3]{300}$ to the $\sqrt[3]{600}$, or of 6·69 to 8·43; that is, to 8·82 or 9·45 miles per hour, according as the speed on the trial trip is taken at 7 or at 7½ miles. To obtain a speed of 15·5 miles, which is the speed of the Arctic in still water, the expenditure of fuel must be increased in the proportion of $(8{\cdot}82)^3$ to $(15{\cdot}5)^3$, or from 6 to 33 tons, disregarding the increase of draft. As a matter of fact the weight of the engines will be augmented in about a two-fold proportion, which will increase the draft nearly 3 feet; or make the draft, after the ballast is removed, about 19 feet, and thereby augment the necessary consumption of fuel to 38 tons. The supply of coal for a 12 days voyage at 50 tons per day would be 600 tons; this additional load would increase the draft on leaving port to 22 feet, which is some 2 feet deeper than the load-line.

If we take the other estimate of the velocity answering to 600 horses-power, viz., 9·45 miles, the amount of coal required, at the velocity of 15·5 feet in still water, will be about 30 tons per day, or 450 tons for a voyage of 15 days. The addition to weight of engines will not be less than 360 tons; and $360+450=810$ tons will just sink the ship to the load-line.

The Arctic would accomplish the voyage in the same time, and carry not less than 700 tons freight. But in doing this her engines would consume about 600 tons more coal than those of the Ericsson in the case supposed. This estimate of the highest possible performance of the Ericsson is so near an approximation to the performance of the steamships of the Collins' line that it must be admitted to be within the bounds of possibility that caloric ships may hereafter compete successfully with these celebrated steam-ships. At least this conclusion seems to follow, unless we have underrated the necessary weight of the caloric engines. It must be left to time to decide the question, whether the full estimated power of the caloric engines can be actually obtained; and whether, therefore, the results which have been indicated, will, from being a mere ideal limit, ever come to be an actual realization.

With her present capabilities the average speed of the Ericsson at sea would not exceed 6 miles per hour (see Journal of the Franklin Institute for February, No. 2, p. 127); and she would require 24 days to perform the voyage to Liverpool (3550 statute miles). It seems highly probable that her speed will be increased by alterations and improvements in her machinery, but it is to be observed that when depressed to her load-line, the full estimated power of her engines will propel her at no more rapid rate than 8½ miles per hour, in still water, and less than 7 miles per hour at sea.

6. *Application to Inland Navigation, &c.*

The weight of the caloric engine, and the large amount of space which it requires, would seem to preclude all hope of applying it successfully, in its present form, to river or lake navigation or to railroad locomotion. (See table on p. 408.) In its application to manufacturing purposes and to the drains of mines, &c., the same objections will have much less force, and a favorable result may therefore be more confidently expected. In this point of view, however, a comparison should be instituted between the caloric engine, and the high pressure steam engine working very expansively.

General Conclusions.

The more important general conclusions to which this comparison has conducted are,

1. That Ericsson's Hot Air engine, as compared with the condensing marine steam engine in its most economical operation, has shown the ability to do the same work with the use of from ⅛ to ⅓ less fuel; and that if its full estimated power should hereafter be developed, the saving effected would be 70 per cent.

2. That, for the same actual power its weight is about three times as great as that of the marine steam engine, and that in case its estimated power should be obtained, its weight would be as much as 30 per cent. greater.

3. That, in respect to the space occupied by the engines and coal, the advantage is decidedly in favor of the steam engine.

4. That, the great weight of the engine in proportion to the power developed, must prevent, for the present, the realization of a high speed in the propulsion of vessels. At the same time it is to be admitted that the full estimated power is adequate to the production of high velocities. Time alone can decide the question whether or not this maximum power is really obtainable.

5. The great weight of the engine, and the space occupied by it in its present form, will in all probability prevent its adoption for the purposes of inland navigation and railroad locomotion, in preference to the steam engine. If used as a land engine,

these features will be less objectionable; accordingly it is only in this form of application, and in those cases of marine navigation in which speed is likely to be sacrificed to economy of fuel, that the caloric engine may be confidently expected to achieve a decided triumph over the condensing steam engine.

Although this discussion has brought us to the conclusion that the new motor is not likely to equal the extravagant expectations which are so widely entertained with regard to its capabilities, still it must be freely conceded that the invention of a new engine in respect to which a just claim to superiority over the steam engine can be asserted, in any particular, is a great achievement, and that the ingenuity and mechanical skill displayed in the invention and construction of the Caloric Engine cannot be too highly extolled.

SCIENTIFIC INTELLIGENCE.

I. Correspondence.

Correspondence of M. J. Nicklès, dated Paris, January 9, 1853.

On the Verification of a Standard Meter.—In my last review, I pointed out the general process followed by M. Silbermann in verifying the meter sent to the United States by the French Republic. It remains to complete the description, which I can readily do with the accompanying drawings received by me from M. Silbermann.

Figure 1 represents the rule of steel (a, a') plunged in a bath of melting ice, by which it is thus kept at an unvarying length; b, b', are the dry points, for marking the length upon the bar under experiment; they are of tempered steel, and very firm; the extremities are turned with care and converge to a point at an angle of about 60°. The distance between the points is 1-200ths of a millimeter less than the length of the meter in the melting ice.

It will be remembered that this compass is applied twice to the rule under trial, first when this rule has been put in melting ice, and afterwards when it has been kept for two hours in boiling water. We obtain thus four marks, to which the form of arcs of a circle are given.

The distance between these arcs is determined by means of the apparatus, fig. 2, contrived by M. Silbermann for comparing the meter sent to the United States with the Governmental Standard. The following are explanations of this apparatus, which may obviously be applied to the study of dilatations in general.

The base of this "Comparator" consists of two rules $a\,a'$, $b\,b'$, of the same breadth and nearly of the same length; they are placed one over the other and firmly pinned together at c', (to the right in fig. 2.) The lower rule, $b\,b'$, is of bronze, the upper $a\,a'$, (upon which the meter under trial is placed,) of platinum. Each is 30 millimeters in breadth. Their other dimensions are as follows:

	Length.	Thickness.
Platinum rule,	1mm·12	3mm·50
Bronze "	1 ·13	7 ·00

The length of the meter is obtained between the heel-points, d, d', (or the extremities of the shorter arms $d\,f$, $d'\,f'$,) of two levers, $d\,e$, $d'\,e'$, one lever at either extremity of the measure; the longer arms of which levers serve to multiply any minute differences of length in meters placed between the heel-points. The axes, $f\,f'$, upon which the levers move, are firmly fixed to the lower rule. The short arms, $d\,f$, $d'\,f'$, are 8 millimeters long, and are curved. The long arms, $f\,e$, $f'\,e'$, are 160 mm. long. These levers are placed vertically, above the rule to which they are joined by the piece supporting the axis of motion. This axis moves between the points of two screws, secured in the support.

The lever $d'\,e'$, (situated on the side a', to the right in figure 2 where the two rules are united together,) serves as a striker against one end of the meter under trial, the axis of rotation (f') of this lever being firmly attached to the rule.

The other lever, $d\,e$, (contact-lever) is brought into contact with the extremity of the introduced meter; and to accomplish this, it is moved by the slide $g\,h\,i$, through the action of a micrometric screw (s), the nut k, of which is fixed to the rule of bronze by means of a projection which unites the two pieces. The amount of movement required of the plate $g\,h\,i$, is measured by the micrometer screw, which is therefore the measuring apparatus, properly so called.

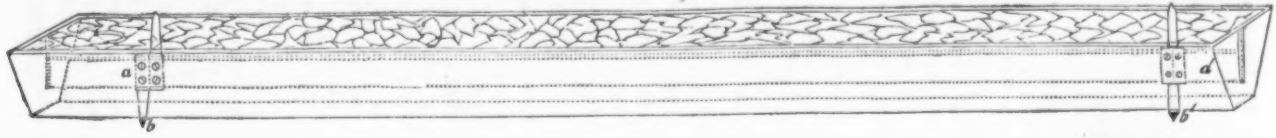
In order not to injure the extremities of the introduced meter, the two levers are held against these extremities only by means of a small spring, l, l', the power of which does not exceed five grammes. The curved extremity d, d', of the small arms, is cylindrical and horizontal, and presents for contact with the introduced meter, an edge 2 millimeters in length.

At the summit m, m', of the piece constituting the support of each lever, there is a zero mark, and also another on the top of the lever; the coincidence of these two gives the requisite length for the interval between the extremities of the short arm of the levers. To increase the precision, five marks are made instead of one, two either side of the zero mark, and the intervals on the top of the lever are slightly less than those on the support, in order that they may act as a vernier; and to give still greater exactness to the observation, there is an eye glass to each support. If the small arms of the levers d, d', are 1-1000th of a millimeter out of the way, it is indicated at the extremity of the long arm by half a division on the vernier, a quantity quite appreciable by means of the lenses.

To make the delicate contact required, for which pushing with the hand alone would be unsatisfactory, there is a piece p, (right end, in fig. 2) which presses against the measure by its side. This piece terminates in a horizontal tail piece q, which connects with a thumb screw, r, not very fine in its thread, that passess through the foot of the support. This screw is situated in the prolongation of the upper surface of the platinum rule, upon which surface the rule under trial rests.

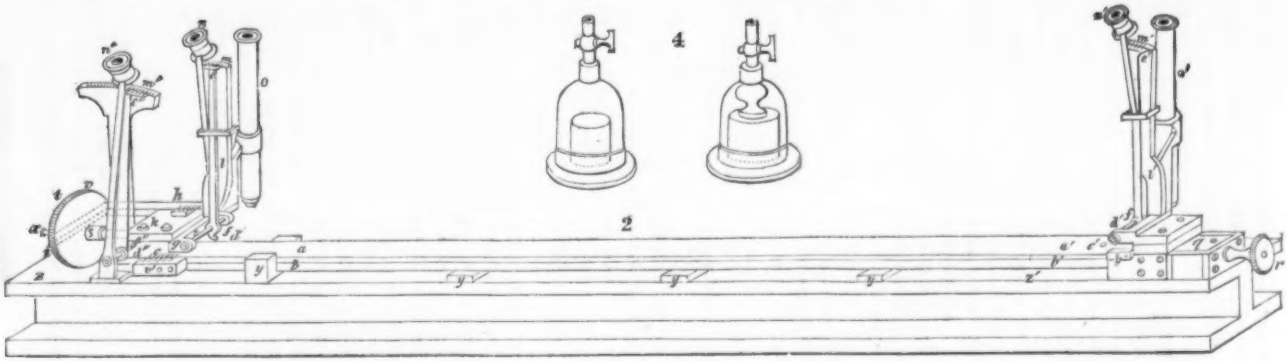
The micrometric screw, s, above alluded to, makes just a semi-millimeter each revolution. The head t, is divided into 500 parts, and subdivided into 5000 by a vernier, (v) fixed to the support. The millimeter is thus graduated to 10,000 parts, which is equivalent to 10-mil-

1



4

2



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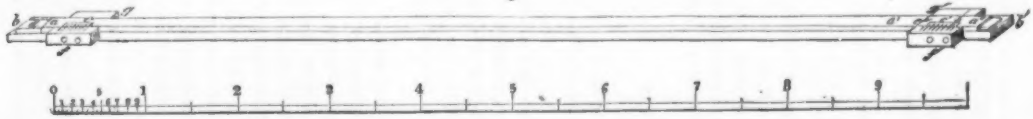


lionths of a meter, or the relation between a meter and a quarter of a terrestrial meridian. This screw turns between two points x, screwed into the slide which supports the contact lever, and is situated in the same line with the points of contact.

The delicacy of the points of contact being ascertained, there is still a condition to be provided for, viz.: the invariability of the distance between the two heel-points of the levers, an invariability constantly disturbed by variations of temperature.

To insure an invariable length in the bronze rule, which serves as a support to the levers, M. Silbermann applies to this rule, the rule $a\,a'$ of platinum, which, as the dilatation of the two metals is very different, makes of the couple a thermometer of Borda (fig. 2); and it indicates for each instant, the temperature of the system. This is the object of uniting the two rules at one end c, by a pin which goes through both, while at the other end, they are free. The difference of dilatation is indicated by a scale c, divided into fourths of millimeters, traced upon the platinum rule. A vernier made of a plate of platinum is fixed against the bronze rule, which divides 24 of these fourths into 25 parts, and indicates thus hundredths of a millimeter. This plate serves also to guide the platinum rule, while the foot of the nut of the micrometric screw guides the rule on the other side.

For multiplying the movements of dilatation of this thermometer of Borda, the lever $d''\,f''\,e''$, (fig. 2) is introduced. The arc e'' which terminates the arm of the lever, $f''\,e''$, carriers a vernier which moves against a divided arc, m'', whose foot carries the axis f'', of the lever fixed to the bronze rule $b\,b'$. The divisions of the vernier register 50ths of a degree of temperature.

This apparatus for the comparisons ("comparateur") rests on several pieces, y, of equal thickness, and these on a support of brass, accurately planed.

The following is briefly the method of using this apparatus in comparing a meter under trial with the prototype standard.

The standard is put upon the Borda thermometer (fig. 2); the whole is placed in ice; by means of r, its extremity is put into coincidence with d', so that the two zero marks $e'\,m'$, are coincident; then by means of the screw t, the slide $g\,h\,i$, is moved until the extremity d of the small arm of the lever touches this extremity of the standard meter, so as to bring into coincidence the two zero marks.

This same operation is performed with the meter under trial and the difference is noted on v. This reading is quite correct, only when the Borda thermometer indicates that the temperature has not varied.

Standard Meter.—The standard meter is made of annealed steel, placed on a rule of bronze which forms with it a Borda thermometer. The free extremities of these two rules carry each a divided scale. The scale of the bronze rule is cut on a silver plate, f; its divisions are fourths of a millimeter. The vernier is fixed upon the steel rule: it consists of a plate of silver imbedded in the surface of the rule and registers hundredths of a millimeter.

This standard meter may be used for comparison with meters which measure a meter either between the extremities, or between marks on the surface. In the former case, the meter is inserted between the

heel-pieces, d, d', and in the other the graduated part of the meter is placed under the two microscopes, o, o'.

The divisions $f f' g$, &c., on this meter serve to correct for temperature and to reduce it to the standard temperature, which is that of melting ice.

The above descriptions will suffice, I think, for repeating the comparisons, and also for generalizing the results, while we wait for the publication of M. Silbermann's memoir. The employment of Borda's thermometer, which is a novelty in this department, is of great importance, as it registers the slightest change of temperature.

On comparing Standard Weights in a Vacuum.—Before leaving this subject of weights and measures, I add a few words on M. Silbermann's process for comparing standard weights in the vacuum of an air-pump, a process deemed impracticable, until accomplished by M. Silbermann, and whose success shows that in the physical sciences there is nothing we need despair of.

The weight under trial is a brass kilogramme. Two bell-glasses (fig. 4) are taken, large enough to contain the weight, equal in volume (0·20 litre) and in weight, and furnished above with a small stop-cock. Each bell-glass is placed on a disk of ground glass, used as a moveable plate.

The disk and bell-glass are united by the method of M. Poinset, superintendant of the Laboratory of M. Payen, at the Conservatory of Arts and Measures; that is, by covering the edge of the bell-glass with a thin band of vulcanized caoutchouc from which the excess of sulphur has been removed by means of a potash lye. The band thus arranged, intervenes between the bell-glass and the plate, and if sufficiently thin, the vacuum is maintained in perfection.

After placing the standard kilogram in one of the bell-glasses, the kilogram under trial is placed in the other. The vacuum is then made in both together by means of an air-pump; hydrogen is introduced before it is complete; after expelling which, by continued pumping, the pressure is so far reduced as ordinarily not to exceed two millimeters, so that the weight of hydrogen left, representing this pressure, is not appreciable to the balance.

The weight to be considered is moreover the difference of the weights of the displaced volumes, a weight inferior to that of the hydrogen, which is itself under this pressure only

$$\frac{0{\cdot}20\text{ lit.}\times 0{\cdot}0898\text{ gram.}\times 3\text{mm.}}{760\text{ mm.}}=0{\cdot}00047\text{ gr.}$$

or hardly 5-hundredths of a milligramme.

After putting the two exhausted bell-glasses, each on one of the scales of a balance and establishing an equilibrium by means of small weights, the bell-glass containing the standard kilogram is removed and replaced by the kilogram under trial. The vacuum is made as before, and reduced precisely to the same degree of pressure, after which the bell-glass is placed on the scale of the balance and poised with a small weight, which weight enters into the calculation.

Correspondence of M. Nicklès dated Paris, March 8, 1853.

Caloric Engine.—The use of hot air as a motive power in place of steam has been the general topic of conversation among men of intelligence, since the attention directed to the subject by accounts in the American papers of the experiments of Captain Ericsson. Reclamations flow into the Academy of Sciences, not for priority as to the idea of employing hot air for producing motion, an old principle, and of unknown origin,* but for the use of a metallic net-work for saving or storing the heat. This idea appears to have occurred independently to Captain Ericsson, MM. Franchot, Lemoine, and Lobereau, who, unknown to one another, have applied it in the construction of machines; it is evidence of their good faith in the question that they have each patented their inventions, which they would not have ventured to have done, if they had been aware of previous inventions of the kind.

M. Burdin, mining engineer, brought out a machine of another kind, using in place of a metallic network, a column of sand, which without doubt is less effectual. He was occupied in the construction of a machine of 8 to 10 horse-power, on this basis, when the revolution in February changed the nature of his labors.

The priority, so much disputed, appears at present to belong to M. Franchot,† as well as to Captain Ericsson, for the latter does not date his title anterior to 1838, which is the same period with the patent of M. Franchot.‡

A machine of this kind constructed by M. Franchot was submitted in 1840 to a commission named by the Academy of Sciences, composed of MM. Poncelet, Séguier, Coriolis, Savary, and Pouillet, and it was put in operation before these judges. M. Pouillet, who was charged with reporting on the engine, used his efforts towards burying the memoir of M. Franchot in the "cartons" of the Academy, with his usual aversion to innovations in general; an aversion which he exhibited before the full Chamber of Deputies, with reference to the Electric Telegraph, speaking of it as Utopian and chimerical, at a time when this admirable invention was already in successful action in the United States.

We do not describe here this machine, as it has only an historical interest, for it does not equal in any respect that of Capt. Ericsson. It has been claimed for Ericsson's machine that it realizes an economy of 95 per cent., and in consequence of this exaggeration, some persons have fallen into the opposite extreme, and have strongly argued before the Academy of Sciences, and the Société d'Encouragement, that the saving is actually nothing, and that the regenerator instead of being an

* In 1806 the Brothers Niepce, afterwards inventors of the daguerreotype, presented to the Academy of Sciences an apparatus which they called a *pyreolophorus*, in which air strongly heated produced the effect of steam. It was the subject of a commendatory report by Berthollet and Carnot.—*N.*

† M. Franchot was the originator of the electro-magnetic pendulum, and also inventor of the lamps called "moderator," which have brought in a short time some millions of francs to the successful speculator, who has appropriated to himself the patent of the inventor.—N

‡ We learn that Ericsson's patent dates as far back as 1833.—Eds.

aid, is a hindrance in the machine, such persons alleging that the greater part of the heat is lost in the state of latent heat, and that there is a set-off for the rest in the resistance which the metallic network offers to the passage outward of the hot air.

MM. Galy-Cazalat and Liais, who have come out as the opponents of Ericsson's invention, do not appear to understand the true use of the regenerator, to which they attribute a uniform temperature after the column of hot air has deposited there its caloric, and deny wholly its value. They might as well deny the possibility of bringing into use the currents of air which escape from a furnace. Besides, these writers calculate that the 155 square meters of wire network in the regenerator must weigh 15,000 kilograms, amounting to 90 kilograms the square meter. But little experience is needed to show that this is not so; a square meter of the wire network of 65 wires to the inch weighs barely one kilogramme. There is more than one mistake in the memoir of M. Galy-Cazalat; and M. Liais errs in like manner. It is to be noted that both of these mechanicians have constructed hot air engines which they claim will operate economically without a regenerator. M. Galy-Cazalat concludes by advising Captain Ericsson to do away with the regenerator, and give, per horse-power, 40 square decimeters to the surface heated. "This surface in the caloric engine," says he, "is so small and so highly heated that it allows two-thirds of the heat to escape uselessly into the atmosphere; so that the economy due to the regenerator, were it real, should be reckoned only with reference to the one-third of the combustible usefully employed." One passage in his memoir meets with general and hearty approbation. "As regards the interests of mechanics, all mechanicians are vastly indebted to Mr. Ericsson and the capitalists who have seconded his efforts. Whatever the result, to Captain Ericsson belongs the honor of having made the first great successful attempt in substituting hot air for steam, in a vessel of the first class."

Engine, using the vapor of water at a high temperature.—The magnificent experiment in the bay of New York has excited special attention in France to the subject of motors in general. Some important facts have come to light within a few weeks, which deserve mention.

The use of the vapor of water at a high temperature has been the subject of extended researches, and its application in the production of motion has been attempted both for stationary and locomotive engines. Whilst I was experimenting on the Lyons railroad upon the magnetic adherence of the wheels and rails,* there was a trial being made at the same time with a locomotive moved by super-calorized steam, the plan of which is still kept secret; and it was afterwards abandoned for the same reason that had led Seguier to lay aside his enterprise of a similar kind, who, on constructing a steamboat to be thus moved, was frustrated by the rapid destruction of the tubes of copper which supplied the steam. M. Belleville of Nancy has taken up this subject, according to MM. Seguier and Jobard, and has met with complete success; the machine constructed by him worked for five weeks at Labriche, near Paris, having been substituted for a steam engine of 29 horse-power, with a saving of 40 per cent.

* See this Journal, this volume, p. 106.

Chemists will be surprised to learn that M. Belleville owes his success to the use of iron for the pipes alluded to. The drawing of this metal into pipes of a certain length—a recent invention by M. Gandillot—has come to the assistance of M. Belleville; and the iron is so perfectly soldered as to resist the strongest pressure.

"To create vapor in like manner as it is destroyed in the worm of a still," says M. Seguier, "was one of the most important problems to be resolved in the present state of science." There is also one other, which is, that of employing vapor directly, without an intervening medium.

Much labor has been spent upon the study of reaction, and the known principle that reaction equals action. But that which is incontestable as a principle, has not yet been established by practice. The invention of M. Belleville will contribute greatly to this end, owing to the facility and the safety with which he is enabled to produce vapors at pressures exceedingly elevated. It appears that M. Jobard only awaits the result, in order to carry out an idea of this kind which he has had under contemplation for several years.

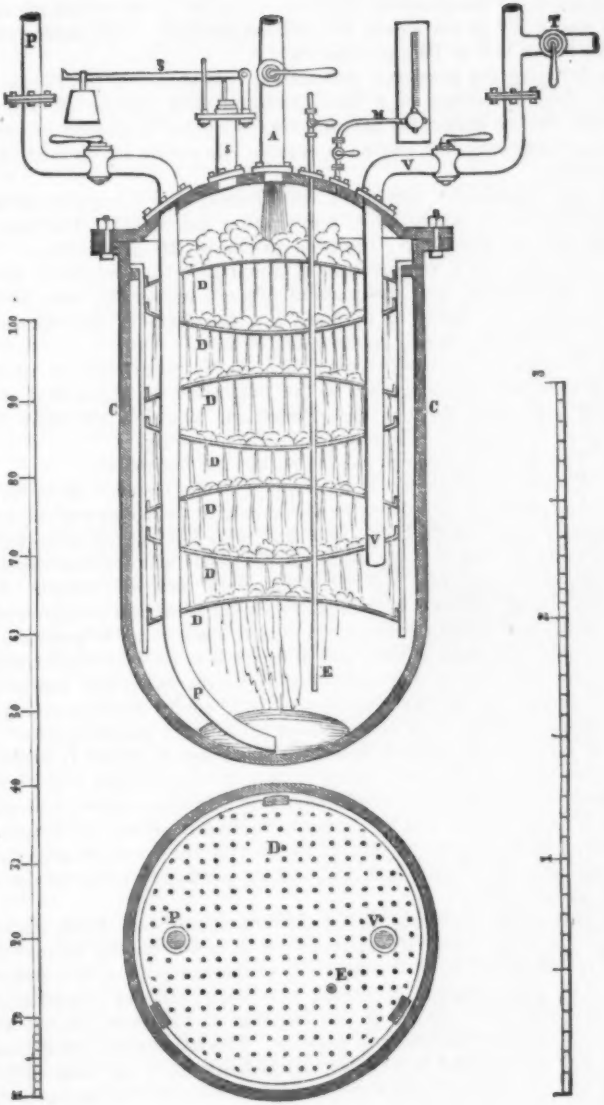
It is evident that by the direct use of steam and the worm of M. Belleville, the steam engine will not occupy one-tenth the space, nor have a tenth part of the weight, nor cost as much by one-tenth, as the ordinary engine.

It appears that the human mind cannot arrive at simplicity except by passing through the complex; it is like a mountain more or less elevated, whose heights must be overcome before the plain at the opposite base can be reached: and when reached, the level seems to be that of the plain left behind. So when a simple solution of a problem is arrived at, we think it an easy natural thought and almost self-evident.

Engine of M. Beauregard.—These views have for a long time been defended by M. Moigno, with especial reference to a machine for supercalorized vapor by M. T. de Beauregard, based on the principle of the *spheroidal state*, discovered by M. Boutigny, and which has led to the invention of an engine of small power which is constantly at work in the manufactory of sperm candles of MM. Jaillon, Moinier & Co., at La Villette near Paris.

The peculiarity of the engine consists in the boiler (fig. 1) which is a cylinder, hemispherically cup-shaped below, having above a cover bolted down, and furnished with all the ordinary apparatus of a steam engine: a supply tube, A; steam pipe for the steam, V; blowing off pipe, P; a steam guage M; safety valve, S; escape pipe for excess of steam, placed at T on the tube which supplies the steam or vapor to the engine. The cylinder contains within 5 to 7 diaphragms, the borders of which are bent upwards, they are alternately convex and concave and pierced with small holes from below upward. By this arrangement, the water passes over a large surface to arrive at the bottom of the cylinder where it enters the spheroidal state. It falls like rain from the first diaphragm to the scond, from the second to the third and so on. Besides, on the first diaphragm, which is convex, the water goes from the center to the circumference; on the second, from the circumference to the center, &c., so that it passes over the largest possible surface, which is farther augmented in extent by the small holes. The diaphragms are kept at the right distance apart by rods of iron.

1.



2.

The steam is taken from between the last diaphragm and the preceding, counting from the top. This arrangement tends to establish an equilibrium of temperature between all parts of the cylinder, and to give uniformly to the steam the tension desired. The usual pressure in the boiler is 5 to 10 atmospheres.

In bringing the generator into action, it is heated dry for some minutes; then by means of a hand pump, a few glasses of water are thrown into the boiler, the steam-guage being put in connection, and 25 minutes afterward, the engine is brought into action which feeds thence the boiler.

In an experiment continued for 9 hours, 351 kilograms of water were evaporated, whose initial temperature was 39° C. The coal consumed was 81 kilograms; pressure produced, 10 atmospheres. This pressure supposes a temperature of about 181° C., and since, according to Baudrimont, iron possesses its greatest tenacity at near 200° C., this temperature tends to increase the resistance of the sides of the boiler, instead of proving unfavorable to it.

M. Boutigny, who has detected through his researches on the spheroidal state, one of the causes of the explosions of steam engines, has studied with care the chances of accident to which the boiler of his invention is exposed. He recognizes the following.

1. The decomposition of water, by the red-hot metal.

2. Excess or deficiency in the supply for the boiler. As to the first, if it takes place, there is actually no increase in the volume of the vapor; 6 volumes of steam ($3H^2O$), *plus* 2 of iron (Fe^2), give $6H+Fe^2O^3$.

As to the second, it is apparent that the vapor will decrease rapidly as the supply is suspended, and the danger will thus be averted. But it may be feared that the bottom of the boiler being no longer supplied with water will redden strongly; and that when water is admitted, this water, spheroidalized at first, will abruptly lose its spheroidal condition from the lowering of the temperature by the continued accession of water, and so by sudden evaporation, produce an explosion—a result that happens under certain conditions in ordinary steam boilers. The fear of such a catastrophe is dissipated on inspecting figure 1, where it is seen that the water falls and evaporates in the diaphragms which are not exposed to a red heat; in consequence of this evaporation, the equilibrium of temperature will be promptly reëstablished and all danger disappear. M. Boutigny has assured me that he has several times exposed the engine to the worst conditions, without producing either of the accidents mentioned.

Engine of M. Andrand, called Electro-caloric.—In 1844, after several preparatory trials, M. Andrand put in action on the railroad from Paris to Versailles an air-locomotive, in the presence of a commission named by government. Although with some points of resemblance, it was not precisely a caloric engine like that of Ericsson, against whom M. Andrand enters no claim of priority. The locomotive acted through air at first compressed in a heater and then dilated by the heat. The air acted at high pressure and the generator consisted of a worm plunged in a fire for the purpose; on passing through this spiral tube, the air was dilated, then on reaching the motor cylinders it underwent additional dilatation, for the concave bottom of the cylinders were furnished with plates of cast iron, which were at a white heat.

The dilatation thus obtained, increased three-fold, according to M. Andrand, the power of the condensed air; whence he concluded that in order to arrive at a practical solution of the problem, the previous compression could be dispensed with, and obtain at the same time the condensation of the air by using for this purpose part of the expansive force of the caloric.

M. Andrand has not put this idea into practice. But in the course of his trials he has several times remarked an unexpected fact which we here mention.

Before making his air-locomotive public, M. Andrand had had it in operation within his workshop. When the reservoir was well filled with condensed air, the fire of the dilatator was made and the iron plates of the bottom of the cylinders were brought to a white heat. This done, it was only necessary to open the stop-cock of the reservoir to set the machine in motion, and cause the two driving wheels to revolve. But while the apparatus was heating up, and before the valve was opened, it happened several times that the machine started spontaneously and communicated to the two wheels a frightful velocity. The phenomena continued from 30 to 40 seconds, then ceased, without his discovering how it was produced or why it stopped. M. Andrand has not succeeded in repeating it at will. Already, some three years before, the same motion, spontaneous and violent, manifested itself two or three times in a small hot-air car which this mechanician had made to move on rails.

What may be the cause of this singular phenomenon? Those who explain everything by a word, who know the precise cause of the cholera, steamboat explosions, the potato-disease, &c., do not fail to reply that the cause is "electricity," and without looking much to the why or the wherefore, they can easily solve many other difficult problems in the same way. M. Andrand, who has, as a mechanician, a well-merited reputation, must have had recourse to the wisdom of one of these Œdipi, for he does not hesitate to make the cause "electricity."

We add, however, that M. Andrand's explanation is not without a shadow of foundation. The two motor cylinders which act independently on the driving wheels, are of different kinds, one wholly of bronze, the other, by chance, partly of cast iron and partly of bronze. But the phenomenon does not appear to be produced in this last cylinder, and never in the cylinder of one metal.

The two cylinders of the locomotive, in which the spontaneous movement was reproduced, also consisted of two metals, the cylinders being of cast iron, and the pistons and bottom of bronze. From this to the phenomena of Galvani, is but a single step; and M. Andrand is convinced that he has been witness of the mechanical work of the electricity excited by the heat.

Setting aside an explanation which elucidates nothing, and which may mischievously make one believe that the problem is resolved when it is hardly presented, we may conclude with M. Andrand, who says: It will be a conquest, both scientific and industrial, of the first order, when we shall succeed in producing at will, this new motive force, and give it a continued action; then two ordinary motor cylinders, moderately heated and fed successively with a very small quantity of air

dry or moist perhaps, will suffice to generate an enormous force, which M. Andrand estimates at 10 or 12 atmospheres, and this with an expense of heat which is altogether insignificant. We shall have then, says he, *electro-caloric* engines which shall leave far behind steam engines, however perfect, and shall realize under volumes of small extent, the marvels attributed to the apparatus of M. Ericsson.

Finally M. Andrand closes his voluminous memoir by the following considerations. "Steam boilers are found, as regards electricity, in conditions analogous to those of our hot-air chambers; it is probable even, that with equal volumes, they contain a much larger quantity. Is it not natural that the phenomena which I have observed, as a matter of chance, in our hot-air cylinders, should be sometimes reproduced in steam boilers?

"It is known that explosions are more violent, the greater the amount of electricity; and on the other hand, that the quantity of electricity is greatest when the steam is of moderate tension, as in steamboats of low pressure engines. And these low pressure engines are the ones which often explode, while the locomotives which are high pressure, very seldom explode." In support of these considerations, M. Andrand says that he has more than twenty times tried to burst vessels of thin sheet iron by compressing in it air at a high temperature, and has not been able to succeed except in tearing them when the pressure was raised to 50 or 60 atmospheres; twice only has he produced an explosion; and these with vessels of copper when other metals were present.

Fusion and volatilization of Platinum and Silica.—Berzelius in his Traité de Chemie (German edition) reports that he had seen a mass of semifused platinum which M. Sefström had obtained by heating in an ordinary furnace filings of platinum mixed with charcoal placed in a crucible. This fact, which had been overlooked, has been carefully studied and submitted to examination on a large scale by M. Deville, so that now the fusion of platinum in a coal fire is no more a difficulty, neither the volatilization of this metal.

In order to verify a fact in analytical chemistry concerning the silicates, M. Henri St. Claire Deville put a platinum crucible closed with its cover, in a Hessian crucible, and placed it in a small laboratory furnace. The combustible consisted accidentally of furnace cinders ("escarbilles") and the whole was subjected to the action of the bellows of a forge. On returning after some time to examine the state of the silicate he saw with surprise that the platinum crucible, as well as the Hessian, was reduced to a paste, perfectly fused.

On reporting the facts to the Academy, M. Deville presented a platinum crucible, which he had caused to melt in lime; he had also a cover of platinum upon which there were numerous globules of volatilized platinum, and also a specimen of pure silver fused in graphite.

As sandstone is perfectly fusible at these temperatures, M. Deville substitutes for it some compact lime containing a little silica, which he had carved into a crucible; the air reached the furnace through a plate of iron pierced with holes arranged circularly to a distance of 5 centimeters around the center.

I have seen the apparatus, and observed the simple and easy method of using it; the humble appearance of this small furnace stands out

the more remarkably in the magnificent laboratory of the Ecole Normale, where M. Deville carries on his labors. This chemist has also succeeded in volatilizing silica, which had already been previously done by M. Gaudin, with a gas blowpipe of his invention, fed by oxygen.

It is essential for success that the combustible should be of the proper kind, and finely divided. The best is made of the residue of the combustion of coal, mixed with cinders such as escape from the grate of a furnace, and are called "escarbilles." Coke and charcoal have produced nothing satisfactory.

M. Deville informs me that he has found no difference between the fused and welded platinum. We add, however, that he has not compared the electro-chemical properties of these metals, nor the action on light.

Pisciculture.—In the science of practical life in Paris, there is a curious subject of the highest value in Physiology, which may be here mentioned. I allude to Icthyogeny or Pisciculture—an important branch of industry which has been created by M. Remy, an humble fisherman among the mountains of the Vosges. Deferring to another time further remarks, I will here state that I have recently seen in the apartment of M. Millet, an arrangement for the breeding of salmon and trout; and in the space of two months, the apparatus of M. Millet, placed upon the marble of a fireplace, has brought out 19,000 young salmons, and more than 10,000 young trout.

Prize.—The Aerostatic and Meteorological Society of Paris offers a prize for the best material for enclosing hydrogen. The prize is a medal of gold, of the value of 300 francs.

II. Chemistry and Physics.

1. *Compass of Tangents.*—The publication of Despretz's memoir on the compass of tangents has induced Gaugain to undertake a series of measurements with this instrument, which have led to results of some interest. It will be remembered* that Despretz took the trouble to demonstrate a fact with which the readers of elementary German treatises on physics have long been familiar, namely, that in the ordinary compass of tangents of Pouillet or Weber, the intensities of the currents are only proportional to the tangents of the angles of deviation when the needle is very short in comparison with the diameter of the metallic ring through which the current passes. Gaugain has found by experiment—what indeed had long been known—that to render the proportionalities of the intensities to the tangents very nearly exact, it is only necessary to place the centre of the magnetic needle out of the plane of the current and in the line perpendicular to the centre of this plane. It was found as the direct result of these experiments, that when we submit a magnetized needle to the action of a circular current, and when the distance from the centre of the needle to the plane of the current is one-fourth of the diameter of the current, the tangents of the angular deviations are almost exactly proportional to the intensi-

* This Journal, xv, 266, March, 1853.

ties. In order to form tangent galvanometers of great sensibility, Gaugain proposes to place the centre of the needle at the apex of a right cone, the angle of which can easily be determined for a needle of any given length. If the surface of the cone be wound with wire covered with silk, each spire will produce a deviation, the tangent of which will measure the intensity of the current, and the conical multiplier thus formed will of course enjoy the same property. The results obtained by Gaugain have been submitted to an analytical investigation by Bravais, who has found that they are readily deduced from Ampere's theory, and that the error committed in supposing an exact proportionality is very small when the radius of the circle is not less than three times the length of the needle. In the case of a needle the length of which is one-sixth of the radius this error would be about $\frac{1}{1250}$ of the whole intensity.—*Comptes Rendus*, xxxvi, 191, *Jan.* 24, 1853.

2. *On the double refraction produced by compression in Crystals belonging to the regular system.*—Wertheim has communicated the results of a second investigation* of this subject, which are as follows:

(1.) Every mineral species belonging to the regular system has a constant co-efficient of elasticity determinable with sufficient accuracy by means of the fundamental tone which is given by plates vibrating transversely with both ends free.

(2.) Crystals which exhibit only the faces of the cube, behave like homogeneous bodies toward external forces. Under equal circumstances the same force always produces an equal difference of path between the extraordinary and the ordinay ray, whatever be the direction in which the force acts, provided only that it is always perpendicular to the surfaces of the crystal.

(3.) In the case of rock salt and fluor spar, which crystallize in cubes, the difference of path for an equal linear compression is almost the same as in different species of glass; the specific doubly refracting power is also the same.

(4.) Alum, which crystallizes in cubo-octahedra, does not behave like an optically homogeneous body, although its elasticity is equal in all directions. The forces which must be applied to produce an equal difference of path often vary as 1 : 4 according to the direction in which they act.

(5.) It has already been shown that in alum the optical and mechanical axes do not coincide; this displacement takes place as if the position of the optic axes had been traced beforehand within the crystal; it is exhibited toward the right or toward the left of the observer according as the one or the other of the two faces traversed by the ray is turned toward him.

(6.) This displacement is the more considerable in pieces perpendicular to the faces of the cube, the less regularly these faces are formed: it is zero or almost zero in crystals with the square faces of the cube, but it increases in proportion as these faces differ from the form of a square, and it is often from 20° to 25° when, in consequence of one of these accidents of formation which we usually consider as

* This Journal, xiii, 411, May, 1852.

of no account, one of the sides of the rectangle is almost twice as long as the other.

(7.) The displacement does not occur in all the six positions of the parallelopiped, but only in the two positions in which the ray is perpendicular to the faces of the cube.

(8.) On the contrary we observe displacements in all the six positions when the parallelopiped has been cut perpendicularly to the octahedral faces of the crystal, but these displacements are of different magnitudes.

(9.) All these phenomena; the unequal optical compressibility as well as the rotation of the optical ellipsoid, appear to have their origin in the permanent effects produced by tensions or pressures which take place in the act of crystallization; we know that the mechanical or molecular elasticity is independent of the changes of form which the body has previously undergone; but the optical elasticity preserves as it were the impression.

(10.) An octahedron of fluor spar presented an example of a displacement of 45°, while cubic crystals of the same mineral offered no trace of it; this fact evidently supports the hypothesis just expressed.

(11.) All the facts which we observe when we employ compression to convert crystals of the regular system into repulsive doubly refracting crystals, are reproduced in a precisely similar manner which we use extension to convert them into positive crystals.—*Comptes Rendus*, xxxv, 276.

3. *On the Electrolytic Law.*—Buff has taken up the consideration of Faraday's law of electrolytic action, and has demonstrated by careful measurements that no portion of electricity however small, can traverse an electrolyte without decomposing an equivalent of the same. By a peculiar arrangement of Daniell's battery, Buff obtained a current which was perfectly constant for several months. The fluid electrolyte was a solution of nitrate of silver, the electrodes were plates of pure silver, and the loss of weight of the positive and gain in weight of the negative electrode were determined by the balance and found to agree extremely well. The results obtained by the electrolysis of a solution of sulphate of copper were also found to correspond satisfactorily, the quantity of copper deposited upon the negative pole being compared with the quantity of silver deposited at the same time from a silver solution. The almost perfect correspondence of the quantities of silver dissolved at one electrode and deposited at the other, as well as the equivalent proportionality between the silver deposited in one electrolytic cell and the copper deposited in another, furnish the most satisfactory proof yet given of the accuracy of Faraday's law.—*Ann. der Chemie und Pharmacie*, lxxxv, 1, *Jan.*, 1853.

4. *Products of the fermentation of Citrate of Lime.*—Personne has studied the fermentation of citrate of lime both in the raw state, as produced by saturating lemon juice with chalk, and as obtained by employing pure materials and adding yeast to bring on the fermentation. The decomposition of the salt proceeds pretty rapidly; the gas evolved is a mixture of carbonic acid and hydrogen; the filtered liquid after the citrate of lime has disappeared yields a white soluble lime salt, which, decomposed by nitrate of silver, gives crystalline silver salts

which on analysis proved to be mixtures of acetate and butyrate of silver. The products of the fermentation of citric acid are therefore hydrogen, carbonic, acetic, and butyric acids, and the decomposition may be represented by the equation

$$4(C_{12}H_{5}O_{11}, 3HO)+4HO=3(C_4H_4O_4)+2(C_8H_8O_4)+20\,CO_2+8H.$$

It is however possible that lactic acid is an intermediate product in this decomposition and that this acid by a further decomposition yields hydrogen, butyric, and carbonic acids.—*Comptes Rendus*, xxxvi, 197.

5. *On the compounds of Glycerine with Acids.*—Berthelot has succeeded in preparing a number of compounds analogous to the natural fats and oils, by the method employed by Pélouze and Gélis in obtaining butyrine, and which is in fact identical with that commonly used in etherifying the fatty acids. The acid is mixed with syrupy glycerine, the mixture heated to 100° and a current of chlorhydric acid passed into the liquid during several hours, the mixture being kept at 100°: the whole is then allowed to cool in the current of gas and then abandoned for hours, days, or even weeks. The mixture is then saturated with carbonate of soda and purified by washing. The acetic combination thus produced is a colorless oil with an agreeable odor and yields glycerine and acetic acid by saponification. The author obtained also *valerine* (phocérine of Chevreul), benzoicine and sebacine. —*Comptes Rendus*, xxxvi, 27.

6. *Alkaloids in Opium.*—Anderson has analyzed several of the rarer alkaloids contained in opium and established their formulas by the examination of their platinum salts. Narcein is found to have the formula $C_{46}H_{29}NO_{18}$, while thebain is represented by $C_{38}H_{21}NO_6$; both these bases give well defined crystalline salts. By the action of nitric acid narcotin was found to yield cotarnin and a new substance which the author terms opianyl represented by $C_{20}H_{10}O_8$. Opianic acid was found to have the formula $C_{20}H_{10}O_{10}$. Hemipinic acid proves to be bibasic and is represented by the formula $C_{20}H_8O_{10}+2HO$. By the action of nitric acid upon cotarnin the author obtained the apophyllenic acid of Wöhler, and found it to be $C_{16}H_7NO_8$, so that it differs from anthranilic acid only by $2CO_2$.—*Journal für prakt. Chemie.*

7. *On the constitution of Mutton Tallow, Human Fat and Spermaceti.*—Heintz has published a continuation of his researches upon the fatty acids and has arrived at interesting and important results. These results in the author's words are as follows:

(1.) The fluid portion of mutton tallow has the same constitution as the corresponding portion of human fat. It consists essentially of olein but contains another fluid fat in small quantity, which yields by saponification a fluid acid having a lower equivalent weight than oleic acid.

(2.) The solid portion of mutton tallow consists of stearin and palmitin; by its saponification we obtain only stearic and palmitic acids.

(3.) The constitution of stearic acid is not represented by the formula $C_{68}H_{66}O_5+2HO$, but by $C_{36}H_{35}O_3+HO$.

(4.) Stearate of soda is $C_{36}H_{35}O_3, NaO$, and the stearates of copper, lead, silver, magnesia and baryta, have a similar constitution and are anhydrous.

(5.) Stearic ether is not an acid compound, but is simply $C_{36}H_{35}O_3 + C_4H_5O$.

(6.) Anthropic acid is a mixture of about 7 parts of palmitic acid and 5 parts of stearic acid.

(7.) Margaric acid is a mixture of about 10 parts of palmitic with 1 part of stearic acid.

(8.) The solid portion of human fat consists only of stearin and palmitin. In this fat palmitin predominates while stearin makes up the great mass of mutton fat.

(9.) Neither stearophanic nor margaric acids are contained among the products of the saponification of spermaceti. The acids resulting from this saponification are the stearic, palmitic, cetic, myristic and cocinic.

(10.) The supposed pure ethal is a mixture of two alcohols, Ethal and Stethal (hydrate of oxyl of cetyl and hydrate of oxyd of stethyl).

(11.) Ethal consists of $C_{32}H_{33}O + HO$ and Stethal of $C_{36}H_{37}O + HO$.

(12.) Spermaceti consists of compounds of the oxyds of cetyl and stethyl with stearic, palmitic, cetic, myristic and cocinic acids.—*Pogg. Ann.*, lxxxvii, 553, No. 12, 1852. W. G.

8. *On the manufacture of Glycerin*; by CAMPBELL MORFIT, M.D.—Glycerin is generally made, on the large scale, either by directly saponifying oil with oxyd of lead; or from the "waste," or spent leys of the soap makers. The first mode of obtaining it is complex and expensive, while in the latter, the difficulty of wholly separating the saline matters of the "waste" renders it impossible to obtain a perfectly pure product. In view of these obstacles, and the increasing demand for the article, both in medicine and perfumery, I submit a new process which has been found, by actual practice, to combine the great and desirable advantages of economy of time, labor and money.

Take one hundred pounds of oil; tallow, lard or "stearin," (pressed lard,) place it in a clean iron bound barrel, and melt it by the direct application of a current of steam. While still fluid and hot, add 15 pounds of lime, previously slaked and made into a milk with $2\frac{1}{2}$ gallons of water, then cover the vessel, and continue the steaming for several hours, or until the completion of the saponification. This is known when a sample of the resulting and cooled soap gives a smooth and lustrous surface on being scraped with the finger nail, and breaks with a cracking noise. By this treatment, the fat is decomposed, its acids unite with the lime to form insoluble lime soap, while the eliminated glycerin remains in solution in the water along with the excess of lime. After it has been sufficiently boiled, it is allowed to cool and settle, and is then to be strained through a crash cloth.

The soap is reserved for sale to stearic candle makers, or else may be reconverted into saleable fat by the process given at pp. 432–445 Morfit's "*Applied Chemistry*."

The strained liquid contains only the glycerin and excess of lime. It must be carefully concentrated by steam heat. During evaporation, a portion of the lime is deposited on account of its lesser solubility in hot than in cold water. The remainder is removed by treating the evaporated liquid with a current of carbonic acid gas, boiling by steam heat

to convert any soluble *bi*-carbonate of lime that may have been formed, into insoluble neutral carbonate, allowing repose, decanting or straining off the clear supernatant liquid from the precipitated carbonate of lime, and further evaporating, as before, if necessary, to drive off any excess of water.

As nothing fixed or injurious is employed in the process, the glycerin, thus prepared, will be absolutely pure.

Baltimore, Md., March, 1853.

III. Mineralogy and Geology.

1. Mineralogical Notices, No. V.

(1.) *New Works.*

Das Krystallo-chemische Mineralsystem von Gustav Rose, 156 pp. 8vo, with 10 wood-cuts. Leipzig, 1852.—A classified catalogue of minerals, based on the system of Berzelius, with their chemical formulas, follows an introductory chapter of 16 pages. The classification includes the following grand divisions,

I. Simple bodies: with the subdivisions, (1) Tesseral, (2) Dimetric, (3) Rhombohedral, (4) Trimetric and Clinohedral.

II. Compounds of Antimony, Arsenic, Tellurium, Sulphur and Selenium.

III. Compounds of Chlorine, Fluorine, Bromine and Iodine.

IV. Oxygen compounds, divided into (A) binary compounds, (B) not binary; the latter subdivided into (*a*) compounds of R^2O, or RO; (*b*) of R^2O^3; (*c*) of RO^2—carbonates; (*d*) of R^2O^5—phosphates and arseniates; RO^3—(*e*) silicates, sulphates, chromates, molybdates, tungstates, tantalates, niobates, pelopates.

This classification is followed by notes on the crystallization and composition of many of the species. The remainder of the volume is a catalogue of minerals, following the same classification, but in which the species under each division are arranged in columns according to their system of crystallization.

Elemente der Mineralogie, von Carl Friederich Naumann, Professor an der Univ. Leipzig. 3d edit. 448 pp. 8vo, with 385 wood-cuts. Leipzig, 1852.—Prof. Naumann in his excellent work, commences with crystallography, the elements of which are presented without entering into mathematical formulas. The physical and chemical characters and classification of minerals occupy the next 90 pages, and are treated with much detail and system. In his classification of species, which is related to that of Mohs, he adopts 16 classes:—I. Hydrogenoxyd; II. Hydrolytes; III. Chalcites; IV. Haloids; V. Earths; VI. Geolites; VII. Amphoterolites; VIII. Chalcolites; IX. Tantalitoids; X. Metalloxyds; XI. Metals; XII. Glances or Galenoids; XIII. Pyritoids; XIV. Cinnabarites or Blendes; XV. Thiolites; XVI. Anthracides. The arrangement is quite similar to that adopted (as a modification of Mohs's system) in the 1st and 2nd editions of Dana's Mineralogy. The author enumerates and describes 643 species of minerals, giving the crystallography and chemical characters of each briefly but with precision, and mentioning the prominent localities.

Lehrbuch der Krystallkunde oder Anfangsgründe der Krystallographie, Krystallophysik, und Krystallochemie, von C. F. Rammelsberg, Dr. und Professor an der Universität zu Berlin, etc. 236 pp. 8vo, with 250 wood-cuts.—This work is a Text-book of elementary Crystallography, in which the subject is presented with clearness, and well illustrated with figures. The Chapter on Isomorphism and other points in chemical crystallography, give special value to the work.

Owen's Report on the Geological Survey of Wisconsin, Iowa and Minnesota. Noticed in this volume, p. 296.

Foster and Whitney's Report on the Lake Superior Region, 2nd Part. Noticed in this volume, p. 295.

Elementos de Mineralogia, par Ignacio Domeyko, Membro de la Universidad de Chile, Professor de quimica y mineralogia en el Colegio de Coquimbo. 382 pp. 8vo. Serena, 1845.—This valuable manual is dedicated to the youths of Chile. No one has done so much towards developing the mineralogy of that country as Prof. Domeyko; and his researches have been rewarded by the discovery of several new species. His work has a special value on account of its fullness upon the ores and mineral products of his adopted land.

(2.) *New Species.*

On Osteolite, a new mineral near Apatite; by C. Bromeis, (Ann. Ch. Pharm., lxxix, 1; in Ausz. Pharm. Centr., 1851, 901; here from Lieb. u. Kopp's Jahresb. f. 1851, p. 813.)—Osteolite is externally a chalky or clay-like mineral, not becoming plastic in water. Within, it is fine granular or compact and resembles lithographic stone. Taste like clay, and adheres to the tongue. BB. acts like pure phosphate of lime. Nitric and hydrochloric acids dissolve it, producing a little gelatinous silica. Analyses (I) by Bromeis, the compact part; (II) the earthy by Ruetz; (III) the intermediate, by Ewald, under Bunsen's direction.

	$\dot{P}$	$\dot{C}a$	$\ddot{S}i$	$\dot{F}e$	$\dot{A}l$	$\dot{M}g$	$\dot{K}$	$\dot{N}a$	$\dot{O}$	$\dot{H}$	
I.	36·88	49·41	4·50	1·85	0·93	0·47	0·76	0·62	1·81	2·28	= 99·51
II.	37·41	49·24	2·75	2·78	1·25	0·79	0·81	0·46	2·34	3·45	=101·28
III.	37·16	48·20	2·03	2·31	*trace*	1·85	0·73	0·43	2·55	3·62	= 98·80

Also a trace of chlorine in No. 1. The mineral contains therefore 86 p. c. of phosphate of lime ($\dot{C}a^3\,\dot{P}$), but fails in the fluorid and chlorid which characterizes apatite. It is a product proceeding from the alteration of dolerite.

Dimorphin, from a Fumarole of the Solfatara, Phlegræan Fields; A. Scacchi, (Mem. Geol. Sulla Campania, Mem. iii, and J. f. pr. Chem., lv, 56.)—Dimorphin is a sulphuret of arsenic; the exact constitution has not been ascertained, but Scacchi deduces from his researches, As^2S^3, which would give 24·55 of sulphur and 75·45 of arsenic. Occurs in small orange yellow trimetric crystals of adamantine lustre; powder saffron yellow. G.=3·58.

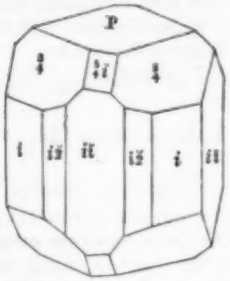
A. Scacchi distinguishes two types of crystals, represented in figures 1 and 2 (copied with a different lettering).

The vertical and two lateral axes have—

In one, the ratio $a : b : c = 1 : 1·287 : 1·153$.
In the other, " $a : b : c = 1 : 1·658 : 1·508$.

The first affords the vertical prisms 121° 38′ and 96° 20′; the octahedron 119° 14′, 111° 10′, 98° 40′; the brachydiagonal prism (basal angle of prism) 75° 40′.

1.



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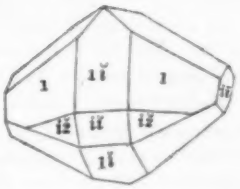


In the second, there is the vertical prism 122° 14′ (calculated, 121° 48′ observed); the octahedron 126° 40′, 120° 40′, 83° 52′; the brachydiagonal prism 62° 12′.

[If we make $b=1$ in the above ratios for the axes, then

For Type I, $a:b:c=1:1{\cdot}287:1{\cdot}153=0{\cdot}777:1:0{\cdot}896$.
For Type II, $a:b:c=1:1{\cdot}658:1{\cdot}508=0{\cdot}663:1:0{\cdot}903$.

The two types differ therefore almost solely in their vertical axes; for the slight difference in the ratio of the lateral axis is within the limits of error of observation. The ratio of 603 to 777 is nearly as $1:1\frac{1}{4}$. If this ratio were exact, it is obvious that the two types would have the same vertical axes, and the difference would be simply a difference in the secondary planes, the octahedron of one being $\frac{5}{4}$P, that of the other 1P. But this ratio is not exact. Adding to 603 its fourth, it becomes 754; and adopting $\frac{5}{4}$ and 1 as the true expressions for the secondary planes mentioned, the two types will differ in the vertical axes, by the small difference between 0·777 and 0·754, and this is in accordance with known differences in other cases dependent on isomorphous substitutions. The axes will then be as follows:—

Type I, $a:b:c=0{\cdot}777:1:0{\cdot}896$.
" II, $a:b:c=0{\cdot}754:1:0{\cdot}903$.

The planes in this case will have the symbols given on the figures (copied, except the lettering, from Scacchi), in which the crystal of type I has for its octahedron, $\frac{5}{4}a:1b:1c$, and that of type II, $1a:1b:1c$. The figures have the shorter lateral axis parallel to the observer.—J. D. D.] In figure 1, according to Scacchi, the angle $P:\frac{5}{4}i=142°\ 10'$; $P:\frac{5}{4}=130°\ 40'$; $i\breve{i}:i\breve{2}=150°\ 49'$; $i\breve{i}:i=131°\ 50'$.

Melinophane, a new mineral; Th. Scheerer, (J. f. pr. Chem., lv, 449.)—This species is near Leucophane and possibly identical with it. Its color is sulphur yellow, citron or honey yellow; lustre vitreous; hardness 5; G.=3·00. Only one distinct cleavage. Composition—

Si	Be	Al	Mn (Mn ?)	Fe	Ca	Mg	Na	F
44·8	2·2	12·4	1·4	1·1	31·5	0·2	2·6	2·3

with 0·3 of niobic acid, zirconia, oxyd of cerium and yttria=98·8. It comes from the zircon-syenite of Frederiksvärn, Norway, along with elæolite, black mica, violet-blue fluor and magnetic iron.

Sunadin, or glassy feldspar.—NAUMANN recognizes this as a distinct species (Min. 3d edit., p. 300). It is monoclinic like orthoclase; but the angle of the rhombic prism is 119° 13′, and the inclination of the axis 63° 55′ (65° 47′ in orthoclase). Formula same as for orthoclase, but often contains lime and magnesia. Common in trachyte and phonolite.

Montmorillonite.—This name is given by Salvetat to a species near Halloysite, analyzed by Damour, from Montmorillon, Department of La Vienne. Formula $\dot{A}l\,\ddot{S}i^3+6\dot{H}$.

On Scleretinite, a new Fossil Resin, from the coal measures of Wigan, England; by J. W. MALLET, (Phil. Mag. [4], 4, 261.)—Occurs in small drops or tears from the size of a pea to that of a hazel-nut. Brittle, with the fracture chonchoidal. Translucent in thin splinters. Color black, but by transmitted light reddish brown; streak cinnamon-brown. Lustre between vitreous and resinous, rather brilliant. G.= 1·136. H.=3. Heated on platinum foil it swells up, burns like pitch, with a disagreeable empyreumatic smell and a smoky flame, leaving a coal rather difficult to burn, and finally a little gray ash. In a glass tube, yields a yellowish-brown oily product of a nauseous empyreumatic odor. Insoluble in water, alcohol, ether, caustic and carbonated alkalies or dilute acids; and even strong nitric acid acts slowly. Composition:—

	Carbon.	Hydrogen.	Oxygen.	Ash.
1.	76·74	8·86	10·72	3·68
2.	77·15	9·05	10·12	3·68

affording the ratio $C^{10}H^7O$=carbon 77·05, hydrogen 8·99, oxygen 10·28, ash 3·68. Taking the number of atoms of carbon at 40, which exists in so many resins, the formula becomes $C^{40}H^{28}O^4$. It is nearest in composition to amber, which contains $C^{40}H^{32}O^4$.

(3.) *Described Species.*

Diamond.—The diamond has been found in the Australian gold region.

Misenite, a hydrous sulphate of potash from Misene, Phlegræan fields; A. SCACCHI, (Memorie geologiche sulla Campania, Mem. iii, and J. f. pr. Chem., lv, 54).—The Misenite is from a hot cavern at Misene, and occurs in silky fibres of a dirty white color. Melts easily when heated and gives out water. Composition:—

$\ddot{S}$	$\dot{K}$	$\dot{A}l$	$\dot{H}$
56·93	36·57	0·38	6·12

Formula, $\dot{K}\,\ddot{S}+\dot{H}\,\ddot{S}$.

Trona.—Efflorescences of Trona or salæratus occur near the Sweetwater River, Rocky Mountains, mixed with sulphate of soda and chlorid of sodium. Three grammes of the salt in dry powder afforded

Dr. L. D. Gale 0·9030 of carbonic acid corresponding to 1·73239 grammes of the sesquicarbonate. (Stansbury's Rep., p. 420.)

Alum from Alum Point, Great Salt Lake. This alum is found by Dr. L. D. Gale (Stansbury's Report, &c., p. 420) to be a manganese alum, and crystallizes in acicular 4-sided (?) prisms. Taste like that of ordinary alum but less strong. It occurs as an efflorescence on a slate rock. The specimen received by Dr. L. D. Gale was recrystallized before analysis, as it had lost part of the water. It afforded in an imperfect analysis

Ḣ	Ṁn	Ȧl	S̄
73·0	8·9	4·0	18·0

Heavy Spar.—Analysis of a crystalline variety from Thurnberg near Durlach, by E. Riegel, (Jahrb. pr. Pharm., xxiii, 348; Lieb. u. Kopp's Jahresb. f. 1851, p. 815.)

Ḃa S̄	Ṡr S̄	S̄i	Ḟe	Ḣ
93·92	0·86	3·75	0·64	0·50=99·67

Arragonite of Thurnberg, near Durlach.—Analysis by E. Riegel, (ibid)—carbonate of lime 96·04, carb. strontian 2·20, Ḟe 0·06, water 0·32=98·62.

Calc Spar.—The crystallography of calc spar has been revised with great thoroughness by F. X. M. Zippe. The whole number of distinct forms is 127, viz: 36 rhombohedrons, 79 scalenohedrons, 7 pyramids, and 5 prismatic including the terminal plane. (Denkschriften der mathem.-naturw. Classe d. kais. Acad. d. Wissensch. in Wien, Bd. iii; and Lieb. u. Kopp's Jahresb. f. 1851, p. 817–820.)

The Carrara Marble, of best quality, afforded P. M. Kæppel, on analysis, (J. f. pr. Chem. lvii, 324), carbonate of lime 98·7654, carbonate of magnesia 0·9002, silica (0·0059) trace of phosphoric acid and loss 0·0961, oxyds of iron and manganese and alumina 0·0825, quartz sand 0·1558=100.

Limestones.—Analyses of Silurian limestones of the Lake Superior region, by Foster & Whitney, loc. cit. p. 192. The limestones contain for the most part a large amount of magnesia.

Marble of Lake Superior Region; Foster & Whitney's Rep., loc. cit., p. 83.

Selenite.—Crystals of Selenite are common in connection with an impure limestone in the Des Moines country, Iowa. D. D. Owen, Rep. Geol. Survey, Wisconsin, etc., 1852, p. 98.

On Lancasterite and Magnesite; J. L. Smith, and G. J. Brush.—This vol., p. 213, 214.

Apatite.—C. Rammelsberg has analyzed the pseudo-apatite of Breithaupt, and obtained the following constitution, showing that it is an impure apatite (J. f. pr. Chem. lv, 486).

P̈	Ċa	Ċa	Ṁg	Ḟe	C̈ & loss
40·30	48·38	5·40	0·14	1·78	4·00

The fluorine was not determined. Only a trace of chlorine was detected.

Phosphate of lime nodules in Silurian rocks of Canada.—W. E. LOGAN in Rep. Progress of Geol. Survey of Canada, 1852, p. 28; with analyses by T. S. Hunt, p. 105. This volume, p. 129.

On Childrenite; C. RAMMELSBERG, (Pogg. Ann., lxxxv, 435).—This rare mineral is trimetric, with the axes 0·67113 : 1 : 0·63912. The crystals are yellow, yellowish brown, and brownish black, and form druses on spathic iron. G=3·28—3·247. H=5. Gives on heating much water, colors the blowpipe flame bluish green, and with the fluxes gives the reaction of iron and manganese. Dissolves in muriatic acid in powder after long digestion, and the solution contains phosphoric acid, alumina, and the oxyds of iron and manganese. Analysis:

	$\dot{P}$	$\ddot{A}l$	$\dot{F}e$	$\dot{M}n$	$\dot{M}g$	$\dot{H}$
	28·92	14·44	30·68	9·07	0·14	16·98
Oxygen	16·20	6·74	6·81	2·03	0·14	15·09

Oxygen ratio for acid, peroxyd, protoxyds and water, 15 : 6 : 8 : 15, giving the formula $(2\,\dot{R}_4\,\dot{P}+\ddot{A}l^2\,\dot{P})+15\dot{H}$.

Quartz.—A large 6-sided prism, 2 feet long, as stated by Prof. C. U. SHEPARD, now weighing 175 pounds, was found at Waterbury, Vt. by Mr. M. M. Carleton. The width of the broadest prismatic planes is 14 inches, of the others, 8 and 9 inches.

Opal.—Analyses by G. BISCHOF (Lehrb. d. Chem. u. Phys. Geol., ii, 1837, Liebig und Kopp's Jahresb, for 1851, 762) of I, a brown shining opal from Trachyte of Rosenau in the Siebengebirge; II, a dull yellowish, ib.; III, a yellow, ibid,—after ignition:

	$\ddot{S}i$	$\ddot{A}l$	$\dot{F}e$	$\dot{C}a$	$\dot{M}g$	$\dot{K}$				
I, *a*	96·12	0·50	3·30	*trace*	0·08	—=100—loss by ignition				5·11
I, *b*	96·00	3·49		——	0·40	0·06=100	"	"	"	5·00
II, *a*	94·49	0·60	4·85	*trace*	0·60	—=100	"	"	"	6·77
II, *b*	94·67	5·26		——	0·02	0·05=100	"	"	"	5·95
III,	95·55	4·37		——	——	= 99·92				

Magnesian Opal, from near Harmanjick, Asia Minor.—J. LAWRENCE SMITH obtained for the composition of this opal, which occurs with serpentine and carbonate of magnesia,

Silica 92·00, Water 4·15, Magnesia 3·00.

It occurs also on the island of Mytilene.

Datholite of Isle Royal.—Analysis of the massive variety by FOSTER and WHITNEY (loc. cit., p. 101).

$\ddot{S}i$	$\dot{C}a$	$\dot{B}$	$\dot{M}n$	$\dot{H}$
37·64	34·68	21·88 (loss)	*trace*	5·80

Gymnite.—A serpentine mineral from the Tyrol, described by LIEBENER and VORHAUSEN, examined by J. Oellacher (Zeitschr. d. deutsch. geol. Gesellsch. iii, 222; im Ausz. Jahrb. d. k. k. geol. Reichsanst. (1850), iv, 608; here from Lieb. u. Kopp's Jahresb. für 1851, p. 804) and F. Kobell (Münch. gelerte Anz. (1851) xxxiii, 1; and ibid) and shown to resemble *gymnite*. It looks like gum arabic, and is brittle, transparent or translucent; color yellowish white to honey-yellow. Taste clayey; adheres a little to the tongue; becomes more transparent in water. H. according to Vorhausen, =2·5—3; G. =1·936—2·155. BB. fuses only on the edges to a white enamel. Easily dis-

solves in concentrated hydrochloric acid, with a separation of flocculent silica. Analyses:

	$\ddot{S}i$	$\dot{M}g$	$\dot{F}e$	Apatite	$\dot{H}$
I. By Oellacher,	40·40	35·85	0·38	0·77	22·60=100·00
II. By Kobell,	41·50	38·30	—	—	20·50=100·30

Formula according to Oellacher, $\dot{M}g\,\ddot{S}i+\dot{M}g\,\dot{H}^2$; Kobell, $\dot{M}g^2\,\ddot{S}i+3\dot{H}$.

Serpentine in Canada.—Mr. T. S. Hunt gives the following analysis (Logan's Rep.) of a serpentine from Ham—a variety of a greenish white color, subtranslucent; H. 3·5.

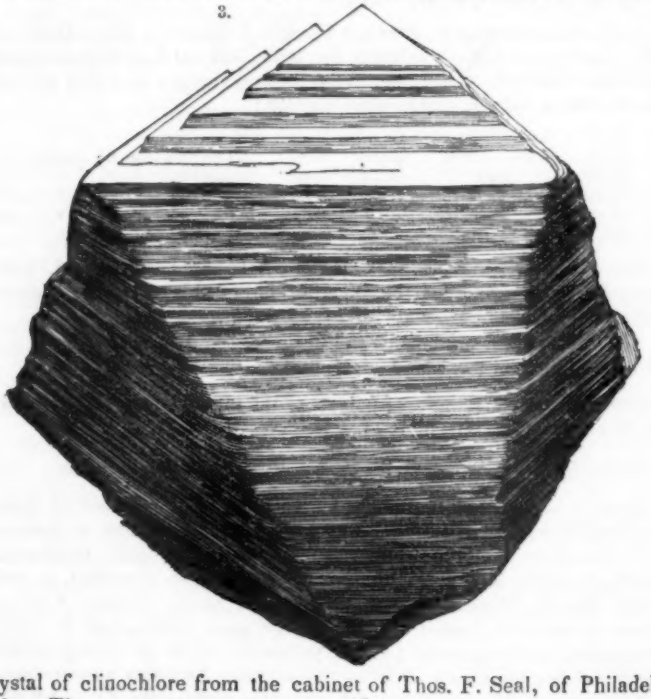
$\ddot{S}i$	$\ddot{A}l$, $\dot{F}e$	$\dot{M}g$ (loss)	$\dot{H}$
43·4	3·6	40·0	13·0

A serpentine of a grayish-green color from Ireland, Canada, afforded Silica 43·70, magnesia 23·46, alumina with peroxyd of iron 23·00, water 11·57=101·73. G. =2·652—2·658. Another serpentine rock from near Nicolet rock, had the specific gravity 2·701.

Kerolite, Bowenite, and Williamsite.—J. Lawrence Smith and G. J. Brush. This vol. p. 211, 212.

Tabergite.—G. Rose thus names Werner's Talc of Taberg in Wermland, which according to Svanberg's analysis is near chlorite.

Clinochlore.—The following is a figure, natural size, of a large

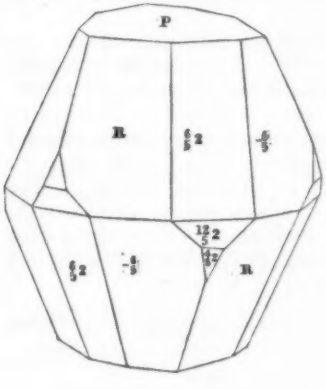


crystal of clinochlore from the cabinet of Thos. F. Seal, of Philadelphia. The measurements vary so widely that we do not at present publish our results. It has a rhombohedral aspect.—J. D. Dana.

Pyroxene.—R. HERMANN has applied his principles of "Heteromerism" to several minerals referred by him to the Pyroxene series. (J. f. pr. Chem., lvii, 193). The paper hardly admits of an abstract.

On the Chlorite of Achmatovsk, in the Urals.—M. KOKSCHAROV has described and figured some remarkable crystals of the chlorite of Achmatovsk, (Verhandl. der min. Ges. zu St. Petersburg, 1850–1851). The form is rhombohedral, and hemihedrally so (or tetartohedral, to the hexagonal prism.) There is a resemblance in some of them to a common form of specular iron. One of the crystals is nearly 6 millimeters in diameter, and is remarkably perfect and symmetrical in its faces. The others are 1 to $1\frac{1}{2}$ millimeters across. Figures 4, 5, 6

4.



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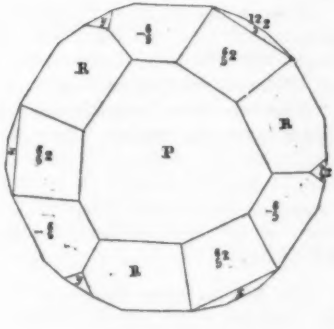

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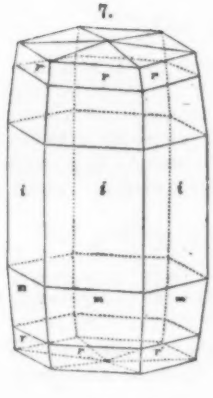

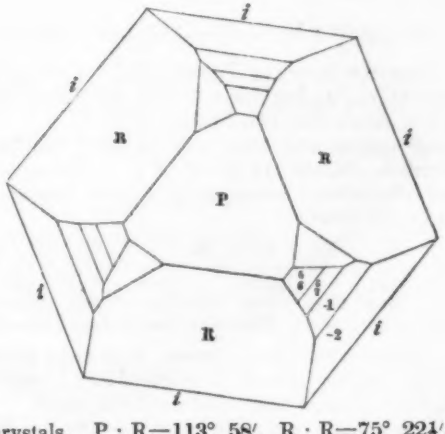

represent two of the crystals. P : R=113° 58′, R : R=75° 22½′, P : $\frac{6}{5}$2=113° 10′, P : $\frac{6}{5}$R ($\frac{6}{5}$ in figure)=110° 20′, $\frac{6}{5}$R : $\frac{6}{5}$R=71° 24′, $\frac{6}{5}$R : R=124° 43′, $\frac{6}{5}$R : $\frac{6}{5}$2=152° 3′, R : $\frac{6}{5}$2=152° 32′, P : $\frac{12}{5}$2=102° 10′, P : $\frac{6}{5}$2=105° 55′. A few of the other angles determined by Kokscha-

rov from different crystals are $+R : -R = 125° 38'$, P (0R) : $\frac{5}{6}R = 118° 5'$, $\frac{5}{6}R : \frac{5}{6}R = 80° 21'$, P : $\frac{6}{7}R = 117° 25'$, P : $2R = 102° 32'$. The vertical axis as stated is 1·94818, the lateral being 1.

Kokscharov reviews the angles of chlorite crystals as given by other observers. In a chlorite from Zillerthal, P : $mR = 104° 10' - 104° 20'$, G. Rose. $\frac{7}{4}R$ gives for this angle 104° 15′. P(0R) : $\frac{3}{5}R = 126° 32'$, near 126° 35′ an angle deduced from Descloiseaux's measurements of a Zillerthal crystal. Breithaupt gives the angle for the terminal edges of a rhombohedron 106° 16′ 15″; this gives 0R : $mR = 136° 9' 17''$; and mR therefore equals $\frac{3}{7}R$, which gives 0R : $\frac{3}{7}R = 136° 2' 50''$. *Lophoite* of Breithaupt has the angle 0R : $mR = 105° 14' - 105° 25'$, and Descloiseaux calculating from the pyramidal angles 132° 40′ and 106° 40′, obtained 105° 33′. mR in this case equals $\frac{8}{5}R$, and 0R : $\frac{8}{5}R = 105° 32'$.

Pennine according to Fröbel gives the angle 0R : $mR = 99° 0'$; this corresponds to $\frac{14}{5}R$; 0R : $\frac{14}{5}R = 99° 1' 16''$. Descloiseaux makes this angle 100° 30′ 40″, which would correspond to $\frac{12}{5}R$; 0R : $\frac{12}{5}R = 100° 29' 37''$. $\frac{12}{5}R : \frac{12}{5}R = 63° 14\frac{1}{2}'$.

Kämmererite of Nordenskiöld (Rhodochrome of G. Rose), afforded Kokscharov the angles, partly by calculation, P : $\frac{23}{5}R = 95° 31'$; P : $\frac{32}{5}R = 93° 58'$, $\frac{23}{5}R : \frac{23}{5}R = 60° 55'$, $\frac{32}{5}R : \frac{32}{5}R = 60° 28' 32''$. The crystal figured (fig. 7) is a hexagonal prism, nearly barrel-shaped, owing to the planes $\frac{32}{5}R$ and $\frac{23}{5}R$, which vary but little in direction from the prismatic planes. In another crystal P : $\frac{8}{7}R = 109° 4' 22''$ and $\frac{8}{7}R : \frac{8}{7}R = 70° 8'$.

The Rhodonite or Fowlerite of New Jersey, in massive specimens of a reddish color, afforded Rammelsberg (J. f. pr. Chem., lv, 486):

	$\dot{S}i$	$\dot{M}g$	$\dot{F}e$	$\dot{Z}n$	$\dot{C}a$	$\dot{M}g$	$\dot{H}$	
	46·70	31·20	8·35	5·10	6·30	2·81	0·28	=100·74
Oxygen,	24·25	7·017	1·85	1·007	1·8	1·104		

On Humite; by C. Rammelsberg. This vol. p. 279.

Pyrosclerite.—The Pyrosclerite (or Kämmererite) of Texas, Lancaster Co., Pa., has been named *Rhodophyllite* by Dr. F. A. Genth, (Proc. Acad. Nat. Sci. Philad., 1852, 117). The mineral occurs in foliated masses, and sometimes in small hexagonal scales or crystals. H.=2·5. G.=2·617 (at 77° F). Color peach-blossom red, grayish and silver white; lustre pearly. Scales flexible, but not elastic. Analysis by Dr. Genth:

	$\dot{S}i$	$\dot{A}l$	$\dot{C}r$	$\dot{F}e$	$\dot{N}i$	$\dot{M}g$	$\dot{C}a$	$\dot{L}i$	$\dot{N}a$	$\dot{K}$	$\dot{H}$	
	33·41		18·15		*trace*	35·86	*trace*	0·28		0·10	12·79	=100·59
	32·98	11·11	6·85	1·43	——	35·22	——	0·28		0·10	13·12	=101·09
Oxy.	17·12	5·19	2·12	0·32	——	14·08	——	0·11		0·02	11·66	

Oxygen ratio, for the water, protoxyds, peroxyds and silica, equals 11·66 : 14·53 : 7·31 : 17·12=1·6 : 1·99 : 1 : 2·34. Fluorine and phosphoric or boracic acid could not be detected.

This mineral has been analyzed also by Mr. Garret; see this volume, page 332.

Delesse has examined (Bull. Geol. Soc., France, [2], ix, 122) a pyrosclerite (?) from the crystalline limestone of the Vosges (at St. Philippe).

It has a clear green color, to grayish green or bluish green, and sometimes emerald green; lustre greasy; hardness so slight that it has been considered a serpentine. G. =2·622. Attacked completely by boiling muriatic acid, without gelatinizing. BB. fuses with effervescence to a white blebby glass. Analysis gave:

Si	Al	Cr	Fe	Mn	Ca	Mg (by diff.)	H
38·29	26·54	*trace*	0·59	*trace*	0·67	22·16	11·65=100

Pyrosclerite is often confounded with serpentine; its structure is usually more or less foliated, though sometimes fibrous.

On Pimelite.—W. Baer (J. f. pr. Chem. lv, 49) has analyzed one of two minerals called Pimelite by Karsten—the harder kind—and obtained, as the mean of two analyses:

	Si	Fe	Al	Mg	Ni	H
	35·80	2·69	23·04	14·66	2·78	21·03=100
Oxygen,	18·60	0·81	10·79	5·69	0·50	18·69

The oxygen ratio for the water, protoxyds, peroxyds and silica, is 18·69 : 6·28 : 11·60 : 18·60, whence M. Baer deduces the ratio 3 : 1 : 2 : 3, and the formula $(Mg, Ni)^3\ Si + 2\ (Al, Fe)\ Si + 9H$.

Specific gravity 2·71 to 2·76. Heated in a tube, blackens and yields water and a bituminous odor. BB. with soda gives a slag, and some nickel may be washed from the charcoal. H. 2·5; lustre waxy; feel greasy; translucent on the edges; does not adhere to the tongue. Dissolves in muriatic acid, even after heating.

The other pimelite of Karsten, called also *Chrysoprase Earth*, was analyzed by Klaproth (Beit. ii, 134).

A silesian mineral analyzed by C. Schmidt (Pogg. Ann. lxi, 388,) and called *Pimelite*, is a different species, and is called *Alizite* by Glocker. Its specific gravity is 1·44—1·46. Composition:

Si	Ni	Mg	Fe	Ca	Al	H
54·63	32·66	5·89	1·13	0·16	0·30	5·23

affording the oxygen ratio 1 : 2 : 6, and the formula $2(Ni, Mg)\ Si + H$.

Pipe-Clays from Nassau.—Fresenius, after separating the sand and hydrated silica from a clay from Nassau, gives the following for its composition, according to one of his analyses: Silica 55·40, Alumina 31·04, water 8·00; in another specimen he found 9·13 of water. Fresenius deduces the formula:

$$Al\ Si^2 + 2H = Si\ 57{\cdot}14,\ Al\ 31{\cdot}72,\ H\ 11{\cdot}14 = 100.$$

Hone-slate or Novaculite.—A very superior quality occurs on Carp River, Lake Superior Region (Foster & Whitney, loc. cit., p. 83).

Zeolites of Scotland.—The Pectolite found on the Isle of Skye at Storr, afforded Dr. A. J. Scott (Jameson's Edinb. New Phil. J., liii, 277):

Si	Al	Ca	Mg	Na	H
52·007	1·820	32·854	0·396	7·670	5·058=99·805

giving the oxygen ratio for the water, soda, lime, silica, 2 : 1 : 4 : 12, whence Dr. Scott deduces the formula,

$$Na\ Si + Ca^4\ Si^6 + 2H = \text{silica } 52{\cdot}6,\ \text{lime } 32{\cdot}4,\ \text{soda } 9{\cdot}1,\ \text{water } 5{\cdot}9.$$

It is in compact fibrous masses, of silky lustre, and is exceedingly tough. G. =2·784. BB. fuses to a bead without intumescence. Partially soluble in hydrochloric acid with the aid of heat, viscid flakes of silica separating.

Scolecite occurs in greenstone in long radiated needles, on the island of Mull. Composition according to Dr. Scott:

$\dot{S}i$	$\dot{A}l$	lime	$\dot{H}$
46·214	27·00	13·450	13·780=100·444

corresponding to the formula of Scolecite.

Natrolite is found at Bishoptown, Renfrewshire, in pure acicular crystals, 2 inches long, "interlaced into a felty mass," associated with mesolite in long radiated needles, and calc spar. Composition, according to Dr. Scott:

$\dot{S}i$	$\dot{A}l$	$\dot{N}a$	$\dot{H}$
47·626	27·170	15·124	9·780=99·700

The Laumonite of Storr in Skye, afforded Dr. Scott:

$\dot{S}i$	$\dot{A}l$	$\dot{C}a$	$\dot{H}$
53·048	22·943	9·676	14·639=100·306

It is associated with stilbite. The same mineral from Snizort in Skye, has been analyzed by Connel.

Leonhardite of Copper Falls, Lake Superior Region.—Messrs. Foster and Whitney (loc. cit., p. 104) give the following analyses of a mineral which resembles Laumonite, but remains unaltered: they were made by Mr. G. O. Barnes, under the direction of Mr. Whitney:

$\dot{S}i$	$\dot{A}l$	$\dot{C}a$	$\dot{H}$
55·96	21·04	10·49	11·93=99·42
55·04	22·34	10·64	11·93=99·95

Algerite.—After an examination of many specimens of this mineral in different cabinets, and especially a fine suite in the collection of Mr. Wm. S. Vaux, I am satisfied that the form of the crystals is a *square prism.* In external appearance, they would not be distinguished from scapolite, and this naturally suggests some relation to that species. —J. D. Dana.

Feldspar of the Granite of the Lake Superior Region.—Messrs. Foster and Whitney (loc. cit.) give the following results of an analysis of this orthoclase:—

	$\dot{S}i$	$\dot{A}l$ & little $\dot{F}e$	$\dot{C}a$	$\dot{K}$	$\dot{N}a$	$\dot{H}$
	66·70	18·68	0·30	9·57	3·58	0·70=99·53
Oxygen,	34·66	8·64		2.63		0·62

Unionite identical with oligoclase; J. Lawrence Smith and G. J. Brush. This vol., p. 211.

On Petalite and Spodumene; C. Rammelsberg. This vol., p. 277.

Spodumene and *Petalite* are reviewed by R. Hermann (J. f. pr. Ch., lvii, 276) and various species referred to the types. Spodumene, Acmite and Laumonite are considered as belonging to the *spodumene family*, and not to the pyroxene family, although so near it in crystallization.

In the application of heteromerism to spodumene, (J. f. pr. Ch., lvii, 276,) he supposes the two fundamental compounds (a)$=\dot{R}^2\ddot{S}i^3+\dot{R}\ddot{S}i^2$; (b)$=2\dot{R}^2\ddot{S}i^2+3\dot{R}\ddot{S}i^2$, and makes the varieties or species to consist of *a* and *b* either singly or in different proportions.

The *Petalite family* is made to consist of petalite, castor, heulandite, desmine (stilbite), edelforsite, neurolite and brewsterite. Petalite is described as monoclinic, like heulandite, the angle between one cleavage face (corresponding to M in fig. 1, heulandite, Dana's Min.) and another less distinct (plane ĕ of figure referred to) being 117° 30′, and a third in the same vertical series, 141° 30′. A plane in the same series observed by Breithaupt in his Castor (corresponding to T in the heulandite figure) makes with M the angle 129°.

Stilbite is recognized as monoclinic, Breithaupt having shown that the ordinary forms are compound crystals and related to heulandite.

Garnet.—A massive reddish translucent garnet from Haddam afforded Rammelsberg (J. f. pr. Chem., lv, 487)

	$\ddot{S}i$	$\dot{A}l$	$\dot{F}e$	$\dot{M}n$	$\dot{C}a$	$\dot{M}g$	
	36·16	19·76	11·10	32·18	0·58	0·22	
Oxygen,	18·79	9·23	2·46	7·21	0·16	0·09	—G.=4·273

Allanite in Canada. Occurs sparingly in thin tables in a feldspathic rock on the mountain road from St. Joachim to Bay St. Paul, about two leagues before reaching the latter place (T. S. Hunt in Logan's Rep., cit., p. 120).

Orthite in Syenite near Dresden.—The similar associations of orthite at Dresden and Hitteroe are pointed out by E. F. Zschau in a paper in Leonh. u. Bronn's N. Jahrbuch, 1852, p. 652.

Mineral resembling Schorlomite.—C. Bergemann (Pogg. Ann. lxxxiv, 486) has analyzed a mineral from Brevig, resembling a little schorlomite but with the form of garnet. It occurs in large crystals with zircon, titanic iron, in feldspar. H. $=5$. G. $=3{\cdot}88$, after heating $3{\cdot}898$. BB. infusible; with soda a yellowish glass; with borax, both when hot and cold, a yellowish green pearl. In hydrochloric acid dissolves easily before heating and with more difficulty after heating. Analysis:—

$\ddot{S}i$	$\dot{F}e$	$\dot{C}a$	$\dot{M}n$	$\dot{T}i$, $\dot{Z}r$
33·35	34·60	25·80	1·81	3·67 = 98·61

There is also a trace of magnesia and potash. Separating the titanic oxyd and part of the oxyd of iron as titanic iron, and the zirconia as zircon, the rest would have the composition of garnet, and Bergemann supposes that this may be the true nature of the mineral.

Mica.—Ettling on a new form of twin crystal of mica. (Ann. der Ch. u. Pharm., lxxxii, 337.)

Phlogopite.—A mica in the crystalline limestone of the Vosges, was found by Delesse (Bull. Soc. Geol., [2], ix, 121) to consist of—

	$\ddot{S}i$	$\dot{A}l$	$\dot{F}e$	$\dot{M}n$	$\dot{C}a$	$\dot{M}g$	$\dot{N}a$	$\dot{K}$	F	loss by ign.
	37·54	19·80	1·61	0·10	0·70	30·32	1·00	7·17	0·22	1·51=99·97
Oxygen,	19·51	9·25	0·37	0·02	0·20	11·73	0·26	1·22		

It is remarkable for the large proportion of magnesia. Formula $3\dot{R}^3\ddot{S}i+\dot{R}^3\ddot{S}i$. Delesse observes that phlogopite occurs in granular limestones, especially the dolomitic, in France as well as in America.

On Emerylite, Euphyllite, Margarite, Mica; by J. Lawrence Smith and G. J. Brush.—This volume, p. 207.

Emerylite.—G. Rose (Kryst.-Chem. Min., 1852, p. 40) makes emerylite identical with diphanite, under the formula $2(\dot{C}a,\dot{F}e)^3\ddot{S}i+3\ddot{A}l^2\ddot{S}i+4\dot{H}$. [The analyses of margarite by Hermann and also by Dr. J. Lawrence Smith and G. J. Brush, prove its identity with margarite. See this volume, pp. 46 and 208.]

Tourmaline.—C. F. Naumann has reviewed the published analyses of tourmaline, (J. f. pr. Chem., lvi, 385,) and after showing that the oxygen ratio for the protoxyds and peroxyds among 29 varieties analyzed by Rammelsberg, varies from 1 : 3 to 1 : 16; he adopts Hermann's view of Heteromerism, in explaining the composition.

Lapis Lazuli in the Cordilleras of the Andes.—Mr. F. Field mentions (Quart. J. Chem. Soc., iv, 331) the occurrence of large masses of a bright blue rock in the Cordilleras, which proved on analysis to be Lapis Lazuli, interspersed with small veins of pure carbonate of lime. The particular locality is not mentioned. It afforded on analysis:—

$\ddot{S}i$	$\ddot{A}l$	$\ddot{S}$	$\dot{F}e$	$\dot{M}g$	$\dot{N}a$	$\dot{C}l$	$\dot{C}a$
37·60	11·21	1·65	0·08	0·36	9·66	15·05	24·10=99·71

On Tourmaline and Epidote; R. Hermann. (Jour. f. pr. Chem., lv, 451.)

Euclase.—An analysis by J. W. Mallet, (Phil. Mag. [4], v, 127,) afforded—

$\ddot{S}i$	$\ddot{A}l$	$\ddot{B}e$	$\dot{F}e$	$\dot{S}n$
44·18	31·87	21·43	1·31	0·35=99·14

The formula deduced by Mr. Mallet is $\ddot{B}e^2\ddot{S}i+2\ddot{A}l\ddot{S}i$, or if alumina and glucina are isomorphous, $(\ddot{B}e,\ddot{A}l)^4\ddot{S}i^3$. Specific gravity, 3·036.

Analysis of *Beryl* from granite of Hirschgasse near Heidelberg, by M. Borntrager; and a *Beryl* from Zwiesel in Bavaria, by W. Mayer, (Jahrb. Min. 1851, 185; Lieb. and K.'s Jahersb. f. 1851, 779.)—

$\ddot{S}i$	$\ddot{A}l$	$\dot{F}e$	$\ddot{B}e$	$\dot{M}n$	
66·90	18·15	2·95	12·20	——	=100·20
66·56	17·82	2·43	12·66	0·11	= 99·58

Orangite.—Analysis by Damour, (Ann. des Mines, [5], i, 587.)—

$\ddot{S}i$	$\ddot{T}h$	$\dot{C}a$	$\dot{P}b$	$\ddot{U}$	$\dot{M}n$	$\dot{F}e$	$\ddot{A}l$	$\dot{K}$	$\dot{N}a$	$\dot{H}$	$\dot{M}g$
17·52	71·65	1·59	0·88	1·13	0·28	0·31	0·17	0·14	0·33	6·14	*trace*

The formula $\ddot{T}h^3\ddot{S}i+2\dot{H}$, is that of *Thorite*, with which the species is identical.

On the Sphene of Grenville, Canada; by T. S. Hunt, (Logan's Rep., loc. cit., p. 118.)—This sphene, named Lederite by Shepard, occurs in crystals and masses in a vein of plumbago, with tabular spar, feldspar, pyroxene, idocrase and rarely zircon and cinnamon-colored garnet. H. =5·5. G. =3·49–3·499, from one locality; 3·510, from

another. Color light clove-brown or chocolate brown; translucent. The following analysis shows it to be identical with common sphene.

Ti and trace of iron.	Si	Ca	Loss by ign.
40·00	31·83	28·31	0·40=100·54

At Montreal, Yamaska, Monnoir and Brome mountains. The crystals are imbedded in feldspar, minute, of an amber or honey-yellow color, transparent, brilliant, and highly modified.

Schorlomite.—Rammelsberg has revised his analyses of this mineral and states that the formula of J. D. Whitney is the correct one.* Rammelsberg writes it $2\dot{R}^2\ddot{S}i+\dot{F}e\ddot{T}i^2$. He obtained, (J. f. pr. Ch., lv, 488,)

	Si	Ti	Fe	Fe	Ca	Mg
	25·24	22·34	20·11	1·57	29·38	1·36
Oxygen,	13·11	8·87	6·03	0·35	8·36	0·54

On Molybdenite from near Reading, Pa.; by C. M. Wetherill, (Trans. Amer. Phil. Soc., x, 345.)—The molybdenite occurs in plates and scales in quartz. G. =4·52. BB. on charcoal, white fumes coating the coal; alone in a tube, fumes of sulphurous acid. In the platinum forceps, colored the outer flame yellowish green. Analysis gave Dr. Wetherill:—

S	Mo	Fe	Si	H
38·198	55·727	3·495	2·283	0·297

affording, if the impurities are excluded, Sulphur 40·668, molybdenum 59·332=100.

On Zircon from near Reading, Pa.; by C. M. Wetherill, (Trans. Amer. Phil. Soc., x, 346.)—The zircon occurs in large crystals imbedded in magnetic iron ore; the largest mentioned measured $1\frac{1}{2}$ by $1\frac{1}{4}$ by $\frac{3}{8}$ in. nearly. Color chocolate brown; opaque; lustre adamantine. Surface uneven and edges rounded as if subjected to an incipient fusion. G. = 4·595. Composition, Silica 34·07, zirconia 63·50, peroxyd of iron 2·02, water 0·50=100·09.

Berthierite.—This mineral has been announced by M. A. Daubrée, (Ann. des Mines, [5], i, 123,) as occurring in the Vosges in the Commune of Lalaye (Lower Rhine) in antimony veins traversing transition schists. It is a steel-gray mineral not lamellated like the sulphuret of antimony in which it occurs. It becomes magnetic on calcination. The proportion of antimony to iron in the ore is about 32 to 18. The antimony veins of the regions are from a meter to a meter and a half in width, but unfortunately they have little horizontal extent, being lost in ramifications, or abruptly disappearing.

Native Metallic Iron.—Dr. Andrews in an examination into the minute structure of basalt, has found evidence of the existence of iron in a native state. After pulverizing the rock and separating with a magnet the grains that were attracted by it, he subjected these grains, which were mostly magnetic iron, to the action of an acid solution of sulphate of copper in the field of a microscope. This salt produces no change with the oxyd, but if a trace of pure iron be present,

* The analyses in Dana's Mineralogy, 3d edit., p. 394, should properly be credited to J. D. Whitney.—J. D. D.

copper is deposited. In his trials, there were occasional deposits of copper in crystalline bunches; the largest of which obtained was little more than one-fiftieth of an inch in diameter. He observes that with 100 grains of the rock, 3 or 4 deposits of copper can usually be obtained. The basalt of the Giant's Causeway affords this evidence of the presence of native iron, but less so, than the Slievemish basalt.

The same result would be produced, if the nickel or cobalt were present in fine grains; but Dr. Andrews considers this very improbable. The same basalt afforded, on microscopic examination, augite, magnetic iron, pyrites and a colorless glassy mineral.

The metamorphic rock of Portrush—an indurated clay of the Lias, somewhat resembling Lydian stone in external appearance—under a microscope is everywhere thickly studded with perfect cubes of *pyrites*, 20 of which could often be counted in the space of 1-100th of an inch square; they measured each way about 1-2000th of an inch. With a magnet, minute particles or crystals of magnetic iron were found in the same rock.

On Nickeliferous iron pyrites, from Kearney Ore Bed, Gouverneur, St. Lawrence Co., N. Y.; by Prof. C. U. SHEPARD, (Proc. Amer. Assoc., vi, (Albany meeting,) p. 230.)—This mineral occurs in botryoidal concretions, somewhat radiated structure and pale bronze color, at the same place with Millerite. H. =5·5. G. =4·863. The presence of nickel was ascertained, but not the proportion.

Limonite containing Vanadium.—A limonite (bohnerz) from Staatswald Hardt, Württemberg, contains according to Dr. A. Müller (J. f. pr. Chem., lvii, 124) about 0·05 p. c. of chromic acid and not over 0·03 p. c. of vanadic acid.

On the Iron Ores of the Lake Superior Region, etc.—Messrs. FOSTER and WHITNEY's Report on the Lake Superior Land District, Part II, 1851, p. 50–77. Ores with a metallic lustre and appearance of purity from the Jackson's Company location afforded

	1. Massive.	2. Slaty.
Oxygen,	29·46	29·09
Iron,	68·07	69·09
Insoluble,	2·89=100·42	1·64=99·82

It is a mixture of the peroxyd and magnetic oxyd. A fine grained ore, from the Marquette Company's ore bed afforded iron 70·22, oxygen 29·53, insoluble 0·20=99·95; corresponding to peroxyd of iron 90·58, magnetic oxyd 9·17, silica 0·20. Some of the ores are pure peroxyds, but many are mixtures of the two oxyds.

Iron ores in the Des Moines Coal Fields.—Dr. D. D. OWEN has detected phosphoric acid in the carbonates of iron of Des Moines, and attributes it to the microscopic Lingulas which occur in it. (Proc. Amer. Assoc., v, [Cincinnati meeting,] 47.)

On Manganese ore from India; by Dr. A. J. SCOTT, (Jameson's Edinb. New Phil. J., 1852, liii, 277.)—The ore from Vizianagram is bluish black. G.=4·50. Breaks with difficulty; powder dark brownish black. Composition—

$\dot{S}i$	$\dot{F}e$	$\dot{M}g$	$\dot{H}$	Red ox. of Mn	O
8·300	12·910	2·339	0·539	73·786	1·864=99·735

The oxyd of manganese corresponds nearly to the sesquioxyd, the percentage being manganese 70·63, oxygen 29·37.

Another ore from Bimlapatam, afforded, besides impurities, red oxyd of manganese 76·117, oxygen 0·655, which is a little less oxygen than is required to make it a sesquioxyd.

Franklinite of New Jersey.—Mr. A. C. Farrington, (Proc. Amer. Assoc., vi, 241) has observed the interesting fact, that the Franklinite of the large vein is strongly magnetic where it adjoins the igneous rock enclosing it, (being taken up by a magnet when pulverized) but gradually diminishes in its magnetism on receding from the walls of syenite, it being perceptible only for four feet. Mr. Farrington inferred that the metal near the walls was protoxyd mainly and peroxyd remote from them, and a mixture in other parts.

Triphyline of Bodenmais.—Rammelsberg has analyzed this mineral (Pogg. Ann., lxxxv, 439) with the following result.

	$\dot{P}$	$\dot{F}e$	$\dot{M}n$	$\dot{L}i$	$\dot{N}a$	$\dot{K}$	$\dot{H}$	$\ddot{S}i$	
Analysis I,	39·35	41·42	9·43	7·08	1·07	0·35	1·28	——	= 99·98
Mean of four anal.,	40·72	39·97	9·80	7·28	1·45	0·58	——		0·25=100·05
Oxygen,	22·82	8·87	2·19	4·00	0·37	0·10			

Formula for the mean result, $3\dot{R}^3\dot{P}+2\dot{R}^4\dot{P}$; for the first analysis which gives the oxygen ratio 10 : 7, $\dot{R}^3\dot{P}+\dot{R}^4\dot{P}$.

The triphyline on alteration, loses its alkali, takes up water and oxygen, the iron and manganese becoming peroxyds. The mineral from Norwich, Mass., and Damour's *Alluaudite* are of this kind. The *Triplite* of Limoges, according to Berzelius, has the formula $\dot{R}^4\dot{P}$.

The *Heterosite* of Limoges, or a brownish violet mineral from this locality, afforded Rammelsberg,

$\dot{P}$	$\dot{F}e$	$\dot{M}$	$\dot{H}$
32·18	31·46	30·01	6·35

giving the formula $\dot{R}^7\dot{P}^4+6\dot{H}$. But reckoning it as a protoxyd compound, the formula becomes, excluding the water, $\dot{R}^3\dot{P}+\dot{R}^4\dot{P}$.

Triplite of Norwich, Mass.—The crystals of this mineral are referred by Shepard (Proc. Am. Assoc., vi, 234) to the monoclinic system, and the following angles taken by the reflective goniometer are given; a rhombic prism, of 130° 45′ to 131° 15′; another exterior, inclined to the preceding, 167°; angle M : T (0P : ∞P ∞) 96°; a clinodiagonal prism making with 0P the angle 108°.

[Prof. Shepard alludes to the fact that J. D. Dana mentions the obliquity of certain of the crystals, as an irregularity, and he regards the above view as removing this irregularity. This mode of viewing them does correspond with the oblique crystals observed. But the irregularity is still a fact, for many of the crystals, (we speak from observation) have the angle M : T, 90°, and these crystals include the smaller ones, which are most likely to give the normal form. There is therefore better evidence, that the crystals are right than oblique; and we believe from our observations that the right prism is also the more prevalent form. There is some doubt as to some of Prof. Shepard's angles. The angle P : M (0P : ∞ P′ ∞) is given at 90°, while P and M make with a plane on the edge intermediate, 108° and 140° 15′; the sum of which angles, *if correct*, would be 270°. The angle between P and

D [$\infty P' \infty$ and ∞P] is stated at 119°; while the angles made by *P* and D with the plane *x*, on the intermediate edge, are given at 138° 45′ and 167°; the sum of which *should* equal 299° (119°+180°).]

Galena.—Galena of the Upper Mississippi, D. D. Owen, Rep. Geol. Survey of Wisconsin, Iowa and Minnesota, p. 60.

White Lead ore of Teesdale, in Durham.—Analysis by J. A. Phillips (Quart. J. Chem. Soc., iv, 175); oxyd of lead 83·56, carbonic acid 16·05=99.61.

On Leadhillite in Newberry District, S. C.; by C. U. Shepard, (Proc. Am. Assoc., vi, 231.)—Occurs in apparently regular hexagonal prisms, and 6-sided very acute pyramids. Color pale greenish or yellowish white.

*Matlockite.**—Rammelsberg has analyzed this ore (Pogg., lxxxv, 141) and deduces the formula, Pb Cl+Pb O, corresponding to 55·62 Pb Cl, 44·38 Pb O.

Molybdate of Lead.—This ore from Wheatley's Mine, near Phenixville, Chester Co. Pa., has been examined by C. M. Wetherill (Proc. Acad. Nat. Sci. Philad., 1852, 55 and 119) without detecting any chromium. The color of the crystals is light red.

Native Copper of the Lake Superior region.—Foster and Whitney observe that the crystals from this region are usually tetrahexahedrous, formed by a bevelment of the edges of a cube. The largest mentioned was one-fourth of an inch in diameter (loc. cit., p. 99).

Crystals of analcime occur at Copper Falls which are penetrated throughout with delicate ramifications of metallic copper, so that if the analcime should be dissolved away, the form of the crystal would still remain in the copper.—*Ib.*

On a Copper ore from between the Mississippi and Kickapoo; by Dr. D. D. Owen (Rep. Geol. Survey of Wisconsin, Iowa and Minnesota, 4to, 1852, p. 53).—This ore is an impure one, resembling chrysocolla, in appearance being of a light green color, waxy lustre and fracture, and very brittle. Analysis of a specimen of average quality, afforded, protoxyd of copper 25·0 (corresponding to 19·87 of copper), peroxyd of iron 48·7, protoxyd of manganese 0·2, insoluble silicates with a trace of oxyd of iron 8·3, alumina 0·6, carbonate of lime 0·8, carbonic acid 5·0, water 11·2=99·98.

Copper ore, containing Gold.—This ore, described by Mr. F. Field, (Quart. J. Chem. Soc., iv, 332,) is soft, of greasy appearance, an intense greenish gray color, somewhat inclining to red, powder bright red. It is from the mine *Altar*, about 30 leagues from Coquimbo, and is associated with pyrites, blende, galena, and copper pyrites. Composition:

S	As	Sb	Cu	Zn	Fe	Ag	Au
30·350	3·912	20·284	36·720	7·260	1·232	0·075	0·003

* In this Journal, xii, 388, from Phil. Mag., [4], ii, 120.

According to M. Domeyko, the ore consists of a mixture of galena, iron pyrites, blende and gray copper, in amorphous quartz as the matrix.

Chrysocolla.—Rammelsberg found in a chrysocolla (J. f. pr. Chem., lv, 488)

	$\ddot{S}i$	$\dot{C}u$	$\dot{F}e$	$\dot{C}a$	$\dot{M}g$	$\dot{H}$
	32·55	42·32	1·63*	1·76	1·06	20·68
Oxygen,	16·91	8·53	——	0·50	0·42	18·31

Formula, $\dot{C}u^3\ \ddot{S}i^2+6\dot{H}$.

Copper ores of Adelaide, Australia.—The following ores are reported as coming from different mines near Adelaide. Red Copper ore, Azurite, Malachite, Chrysocolla, Atacamite, with specular iron, Galena and native Bismuth. The last is accompanied with Bismuth ochre and Iron ochre in a red flinty rock.—A. L. Sack, in Jahresb. nat. Ver. Halle, 1851, 57.

Arsenical Nickel.—An ore from Allemont afforded Rammelsberg (J. f. pr. Chem., lv, 486):

S	As	Ni	Fe
2·29	71·11	18·71	6·82—G=6·411

Chloro-bromid of Silver from Chili.—This ore afforded Domeyko (Elementos de Mineralogia, 1845, 203), in three trials:

Chlorid of Silver, .	51·0	52·8	51·0
Bromid of Silver, .	49·0	47·2	49·0

His specimens were from Chañarcillo; they were at times crystallized in shining cubes and cubo-octahedrons, having an asparagus or pistachio green color. G. =5·31—5·43. The formula deduced is Ag Cl+Ag Br. Other varieties of a grayish green color, varied much, affording of the chlorid, 72·9, 65·6, 81·4, 66·4 per cent. The last was from Quillota, the others from Chañarcillo.

Mr. P. Yorke has recently analyzed similar crystals (Quart. J. Chem. Soc., iv, 2) from Chili, and obtained, Chlorid of Silver 53·2, Bromid of Silver 46·8. Whence he has the formula 3Ag Cl+2Ag Br=Ag Cl 53·7, Ag Br 46·3. Specific gravity 5·53.

Cinnabar.—J. Schabus has investigated the crystals of this mineral, and obtained for the fundamental rhombohedron, 92° 37′ 6″, the inclination of the faces on the terminal plane (0R) being 127° 5′ 45″. The angle of the rhombohedron —2R is 71° 47′ 10″; $-\frac{2}{3}$R=110° 7′ 44″; $-\frac{1}{2}$R=101° 56′ 30″.

Cinnabar of California; by A. Bealey.—Specimens of this cinnabar afforded the specific gravity 4·410, and the composition:

Quicksilver, . .	69·36	70·13	69·90
Sulphur, . .	11·38	11·26	11·29
Iron, . . .	1·23	——	1·23
Lime, . . .	1·40	——	1·40
Alumina, . .	0·61	——	0·61
Magnesia, . .	0·49	——	0·49
Silica, . . .	14·30	14·52	14·41

* Peroxyd of iron and alumina.

The Almaden ore affords quicksilver 37·79, sulphur 16·22, iron 10·36, silica and alumina 35·12. The ore of Moschellandsberg, gives quicksilver 66·86, sulphur 11·43, insoluble residue 17·09; and that of Wolfstein, 18·00 p. c. of quicksilver.

Crystal of Native Gold.—Prof. C. U. SHEPARD describes (Proc. Amer. Assoc., vi, 231) a crystal measuring $\frac{2}{10}$ths of an inch across, weight 121·1 grains. Form the pentagonal dodecahedron. The edges are raised, as in many other California crystals of this metal.

Gold in Pennsylvania.—Dr. C. M. WETHERILL mentions (Trans. Amer. Phil. Soc., x, 350) the occurrence of gold in the earth obtained on digging a well; the exact place is not certain, but it was probably in Franconia township, Montgomery Co. Several rocks of the neighborhood on trial proved to contain gold in traces along with pyrites and magnetic iron. In the earth from the well, along with the spangle of gold, a white malleable particle of metal was found which gave the reactions of native *tin*. Judging from the amount of gold obtained, one hundred pounds of the earth would afford 0·4 grammes of gold, worth about 26½ cents.

Gold of Canada.—Specific gravity of worn fragments of gold from the R. du Loup, 15·761, 16·490, 16·654, 17·60, 17·77. The third specimen after being hammered to a thin plate, and twice annealed, had the sp. gr. 17·024; and the fifth after the same process, 17·848. These two afforded, (I) gold 86·40, silver 13·60, (II) gold 87·77, silver 12·23. A third in fine scales, gave gold 89·24, silver 10·76; G. = 16·57.

Gold in Vermont.—This volume, p. 174.

Iridosmine and Platinum of California,—associated with a probably new element; Dr. F. A. GENTH, (Proc. Acad. Nat. Sci. Philad., 1852, 209,) this volume, p. 246.

Platinum and Iridosmine in Canada.—The gold washings of the Rivière du Loup and R. des Plantes, afford grains of Platinum; there are also tin-white grains, generally hexagonal in form, which prove to be Iridosmine. (T. S. HUNT in Logan's Rep., cit., p. 120.)

On the Crystallization of Chondrodite; by J. D. DANA.—The chemical identity of Humite and Chondrodite is well known, but the crystallography of the two has not been shown to be accordant. The writer has given in his Mineralogy (2d edit., p. 388, and 3d edit. p. 280), and in this Journal, vol. xlvi, fig. 6, p. 381 (1846), the only figure of a crystal of chondrodite yet published. It represents an acute oblique rhombic prism, terminating in large pyramidal planes, lettered $\breve{e}$ and $\breve{e}$, and having also the planes of a clinodiagonal prism (a); M : M (over side edge) = 112°, M : $\breve{e}$ = 157°, M : $\breve{e}$ = 136°; $\breve{e}$: $\breve{e}$ (in the same pyramid over clinodiagonal edge, or plane a) = 127°, a : a over the summit 85°. The surfaces were not quite smooth and the angles were given as approximations only.

We can now exhibit the resemblance to Scacchi's figures of Humite, in Pogg. Ann., 1851, Ergänz., ii, 161, and this Jour. [2], xiv, 175. The hemihedral form of humite is represented evidently in the chondrodite. Consequently the planes M and M are planes of an orthodiagonal prism.

See for comparison Scacchi's figures, and p. 181, of volume xiv, of this Journal. The most common plane of the orthodiagonal series in Humite, and the only one occurring in all the types, is our $\frac{1}{2}\breve{i}$ or $\frac{1}{2}$-$\breve{\alpha}$, (in Scacchi's figures, *i*2 of Type I and III, and *i* of Type II); and the front angle of this prism, taking the mean of the three types, is 112° 2′ (111° 28′ for Type I, 115° 6′ for II, 109° 31′ for III); and this is actually the *angle M : M of chondrodite.*

Again, M : ĕ=136°. Now $\frac{1}{2}\breve{i}$ ($\frac{1}{2}$-$\breve{\alpha}$) in Type III, makes an angle with $\frac{4}{3}$-$\breve{2}$ (Scacchi's n^3)* of 134° 23′. Again, M : ĕ=157°, and this is very nearly the angle of $\frac{1}{2}\breve{i}$ ($\frac{1}{2}$-$\breve{\alpha}$) on $\frac{4}{5}$ or $\frac{4}{7}$ (r^4 or r^5 of Scacchi). But the inclination of ĕ : ĕ over *a* is 127°; and this equals nearly the angle between $\frac{4}{3}$-$\breve{2}$(n^3) and $\frac{4}{7}$(r^5), one above and the other below the plane of the lateral axes, this angle being according to our calculation 126° 52′. Considering the dissimilarity of the three types in Humite and the unevenness of the surfaces measured, the coincidences are as close as could be expected.

Again, the prism *a* has the angle 85°; and calculation gives for the corresponding angle of α-$\breve{2}$ in humite (a plane not given by Scacchi but between his *o* and *o*2), 85° 34′. There is also another plane (ă) in the figure of chondrodite which is probably the brachydiagonal prism 4-$\breve{\alpha}$, judging from the inclination of this plane on the edge between ĕ and ĕ, which according to the writer's observation was 168°.†

Note on Tabular Spar or Wollastonite; by J. D. Dana.—In the usual mode of viewing the crystals of this species, the relation to Pyroxene which exists is not shown. But making the clinodiagonal the vertical axis, there is then a vertical prism of 87° 28′ (*e*, *e*′, in Brooke and Miller's figure), varying but 23 minutes from that of pyroxene. The inclination of the axes is 69° 48′. The vertical axis in tabular spar is about one-fifth shorter than in ordinary Pyroxene, and this is the main point of distinction in the form of the crystals.

2. *Notice of a crystal of Fischerite;* by Nicholas Kokscharov, (communicated for this Journal.)—The Fischerite occurs in small translucent crystalline plates and crystals in the fissures of a ferruginous sandstone, near Nischne-Tagilsk in the Urals. Stschourowsky considered the crystals of this mineral to be hexagonal prisms; but the measurements which I have made show that they are rhombic prisms and not hexagonal. The acute edges of the prism are either truncated or beveled, and the crystals terminate in a flat summit plane. By means of the reflective goniometer I have measured the angles of two different rhombic prisms, obtaining for one, 118° 32′ (mean of 5 trials) and for the other 99° 56′ (mean of 3 trials). The first measurements should have the preference; and taking the prism as the prism of the fundamental series, we have, for the vertical (*a*) and lateral axes (*b*, *c*) the ratio $a : b : c = x : 1{\cdot}68196 : 1$

also the prism αP=118° 32′ and 61° 28′, and the prism $\alpha P\breve{2}$=99° 52½′ and 80° 7½′; $\alpha P : \alpha P\breve{\alpha}$ =120° 44′, $\alpha P\breve{2} : \alpha P\breve{\alpha}$ =139° 56¼′.

* In our copies of Scacchi's figures, his planes *r*, are made of the general form *mP*, his planes *n*, of the form *mP*2, and his *ms* of the form *mP*3. In giving the crystallographic symbols above we omit the *P*.

† In the analyses of humite, p. 279, Fe, should be Fl.

3. *On Argentiferous Galena from Arkansas;* by Prof. W. W. MATHER, (communicated for this Journal).—Some of this ore from a locality not communicated, was lately sent me for cupellation. Different specimens afforded silver, varying from 44 to 71 ounces of silver to the ton of lead. I have cupelled hundreds of lead ores, and although I have never cupelled one without finding a trace of silver, there are few as rich as the one above mentioned.

4. *On the alleged great Coal Bed of Perry County;* by Professor W. W. MATHER, (communicated for this Journal.)—Mention has been made in your Journal, and in the papers, about the coal bed said to be more than 100 feet thick, and some have quoted me as authority for such statements. I had never seen it, neither had any one on the Geological survey of Ohio seen or described it, till last autumn, when I was called to examine it professionally. The slides of coal on the hill side, and a thin seam of coal in place in the bed of the small stream below, and the thick seam of coal 12 to 17 feet thick near the top of the hill, are the obvious causes of the great mistake in the thickness of this coal bed. Persons not acquainted with modes of examination, and the liability of deception, seeing the coal in the hill and along the slope of the hill, where slides had occurred but were not recognized, and coal in place in the Run, inferred that the whole hill from the upper to the lower beds was a solid mass of coal. Although we have heavy beds of caking coals, dry burning bituminous coals, and cannel coals of superior qualities in inexhaustible abundance, I have seen no coal bed in Ohio exceeding 17 feet in thickness. Many of the hills however, contain several different seams of coal, and sometimes two or three of them are workable. Iron ore and limestone are associated with the coal in the same hills, and in some instances, coal, limestone and iron ore form contiguous beds with no intervening materials, and of workable thickness. The iron region of Ohio is now being intersected by numerous railroads, furnaces are in operation, and others are building, and the time is not very far distant when that district will be what South Wales now is, and coke or the raw dry burning coals will be the only fuel used for smelting. The iron ores are so abundant that the lands on an average will yield 5,000 to 10,000 tons of iron per acre.

5. *On the supposed bed of Coral at a high elevation, on the Island of Maui;* by Dr. C. F. WINSLOW, (from a letter to J. D. DANA, dated Waltham, Mass., March 13, 1853.)—In your paper on Changes of Level in the Pacific Ocean, published in the March No. of the Am. Journ., at pages 171 and 172, I notice the account given you by my friend, Rev. Mr. Andrews of Molokai, of the existence of coral formations on the elevated parts of West Maui. In reference to the account as evidence of the modern elevation of Maui many hundred feet above the ocean, you observe that it should be received with great hesitation, until further examined. In this you are right. I have been over the regions many times, and examined them with some care. My first impression, like that of Mr. Andrews, on simply looking at the rock, was that it was calcareous. I took specimens with me for chemical experiment, to decide the question of its organic origin. Sulphuric acid exhibited no observable reaction nor disengagement of gases, and I consequently doubted its calcareous character. Afterwards, in conversation with

Rev. Mr. Alexander, (a very acute and highly informed gentleman who is the Principal of the Lahainaluna Seminary,) on the nature and origin of this rock, he informed me that his first opinions were similar to my own, and that he had submitted it to sufficient examination to convince him that there was *no lime* in its composition. This belt of rock is about 400 or 500 feet of perpendicular elevation above his residence, and about 1200 feet above the sea.

From the evidence in my possession on that point, I think you may assume, without fear of contradiction, that no coral formation exists on the very elevated side of West Maui.

IV. Botany.

1. *Principles of the Anatomy and Physiology of the Vegetable Cell;* by Hugo von Mohl, M.D., etc., Prof. Bot. Univ. Tubingen, etc. etc. Translated (with the author's permission) by Arthur Henfrey, F.R.S., etc. With an illustrative plate and numerous wood-cuts. London: Van Voorst, 1852, pp. 158, 8vo.—We desire in a special manner to commend this condensed treatise not only to botanists, but to animal physiologists, to medical students, and to all who would obtain a clear view of the present state of vegetable anatomy and physiology,—a knowledge of which, most interesting in itself, is almost indispensable to the correct understanding of the minute anatomy and physiology of animals. Prof. Mohl is, without question, the first of vegetable anatomists, and his statements carry with them the highest authority on this class of subjects. We copy the short preface which he has contributed to the English translation, as it gives a clear view of the nature and scope of the work.

"Mr. Arthur Henfrey having informed me that he intends publishing an English translation of the present treatise, I take this opportunity of making known to the English reader the purpose I had in view in the preparation of the book. The following pages were not originally intended to appear as an independent work, or to give a summary of the wide subject of the Anatomy and Physiology of Plants, but appeared as an article, in the 'Cyclopedia of Physiology,' published by Dr. Rudolph Wagner, of Göttingen, drawn up to furnish students of Animal Physiology, and more particularly the medical profession, with a review of the anatomical and physiological conditions of vegetables (of the cell), in order to enable them to form a definite judgment upon the analogies which might be drawn between the structure and vital functions of animals and plants. This intention, together with the circumstance that I was compelled to crowd the whole exposition into the space of a few sheets, rendered it necessary to direct especial attention to the individual cell, as the fundamental organ of the vegetable organism. Since, however, the cell only presents itself in anatomical and physiological independence in the lowest plants, and since, in the more highly organized plants, both the structure and the physiological functions of the individual cells become subject to greater dependence upon the other parts of the plant, in proportion as the collective organization of the vegetable is more complex; moreover, since functions then present themselves, of which no trace can be found in the lower plants, it

became requisite to take account of the plants of higher rank, and of the various organs which these possess. The treatise, therefore, contains, if an imperfect, still in many respects, a more extensive resumé of Vegetable Physiology, than might be conjectured from the title.

"Unhappily, the Physiology of Plants is a science which yet lies in its earliest infancy. Few of its dogmas can be regarded as settled beyond doubt; at every step we meet with imperfect observations, and consequently with the most contradictory views; thus, for example, opinions are still quite divided regarding the doctrines of the development of the cell, of the origin of the embryo, and of the existence of an impregnation in the higher Cryptogams. Both in these and in other cases, the small compass of the present treatise forbids a more extensive detail of the researches upon which the opposing views are founded; I hope, however, that I have succeeded in making clearly prominent the chief points upon which these contests turn, and thus in facilitating the formation of a judgment by the reader; and I have never neglected to indicate the literature from which further instruction is to be derived."

It may be well to notice the views of so excellent an observer upon sundry points which have been more or less matters of controversy. As to the milk-vessels, or vessels of the latex, Mohl inclines to adopt the view that considers them as intercellular passages which have acquired membranous linings. (p. 2.) He denies that the membrane of nascent cells is soluble in water, as Schleiden states. (p. 9.) He briefly states the grounds on which, in his controversy with Harting and Mulder, he successfully maintains that the primary cell-membrane is thickened by successive concentric layers of cellulose deposited on its inner face. The combination of spiral markings and pits on the wood-cells of Taxus and Torreya, as also in the Linden, is explained by considering the former to belong to a second layer or deposition, within that to which the pits belong. This tertiary membrane or deposit forms the spiral fibre or band in the cells of the seed-coat of Collomia, the hairs of the achenium of Senecio, &c. (p. 18.) The whole subject of spiral and other markings, rings, dots, slits, reticulations, &c. on the walls of cells is expounded in a masterly and convincing way. Mohl maintains, (p. 28), as he had done in the *Botanische Zeitung*, that cellulose forms the basis of all vegetable membranes in the higher plants, and that what Mulder regarded as peculiar compounds are combinations of cellulose with foreign infiltrated deposits, which interfere with the chemical reactions of cellulose, but which may be removed by previous maceration in caustic potash and nitric acid. He now maintains, in opposition to his early view (still defended by Schleiden) that the *intercellular substance* is a product or secretion of the cell, and not an universally distributed mass in which the cells are imbedded. (p. 33.) He shows that the thickened "*cuticle*" of Unger, Mulder, Harting, &c., consists of secondary layers of cell-membrane, deposited from the inside, and infiltrated with some substance that is colored brown by iodine; with the exception of an extremely thin external pellicle, the real *cuticle* of Brongniart, which is probably a secretion from the surface of the cell, like that which forms the outer coat of pollen-grains. (p. 35.) He insists that the layer of protoplasm, his *primordial utricle*,

lining the cell is a soft and delicate membrane, and not a mere layer of mucilage (p. 37); the mode in which this is constricted and a partition formed by an inward growth at the fold, in the multiplication of cells by division, is very clearly explained. (p. 50–53.) Free cell-formation is said to occur, in Phænogamous plants, only in the embryo-sac, in which both the embryonal vesicle, or rudiment of the embryo, and the cells of the albumen, originate in this manner; in the Cryptogamia, only in the formation of spores in certain cases, as in the Lichens (p. 58); contrary to the view of Schleiden, who long maintained this to be the universal, and lately a general, mode of cell-production. Schleiden's original account of the process of the formation of a free cell from a nucleus is directly controverted in all essential points; the nucleus, according to Mohl, being always central, and at no time connected with the cell-membrane, but always enclosed in the primordial utricle. A nucleus, or mass of nitrogenous substance first has the primordial utricle, or nitrogenous membrane, developed over its surface; and then the cell-membrane (of cellulose) is deposited upon this. In Cryptogamous plants, such masses, of larger or smaller size, may become coated with a cell-membrane without any proper nucleus appearing. (p. 57–60.) Thus much for what relates to the *anatomical condition of the cell.*

Under the second head, the *Physiological Condition of the Cell*, our author treats first, of the cell as an organ of nutrition, next, as an organ of propagation, and finally, as an organ of motion. He pronounces against the Knightian doctrine, that plants ultimately degenerate and perish when propagated for generation after generation by division (from the bud). (p. 64.) That the crude sap, though absorbed by the parenchymatous tissue of the root, ascends through the woody tissue, and that the assimilated sap returns through the bark, and thence more or less into the wood by means of the medullary rays, is very neatly shown. "A few simple experiments leave no doubt about this. * * If the bark of a plant, best of a tree, is cut through in a ring down to the wood, there is no interruption of the flow of sap to parts situated above the wound; but if the wood is cut through, the greatest care being taken to avoid injuring the bark, that portion of the plant above the wound dries up at once. From the wood of the stem and branches the sap flows onward into the leaves, as is proved by the powerful expiration of watery vapor from them. Before the sap has reached the leaves it is incapable of being applied to nutrition; consequently the vegetation of a plant comes to a stand-still when it is deprived of its leaves. The sap ascending from the root to the leaves is thence termed the crude sap. It undergoes a chemical change in the leaves, rendering it fit to be applied to the nutrition of the plant. To this end the sap flows backwards from the leaves through the bark to the lower parts, as the following circumstances testify. If the bark is cut off the stem in a ring, the growth of the portion below the wound stands as it were still; the stem becomes no thicker; in the potato plant no tubers are produced, &c.; but, on the other hand, the growth above the wound is increased beyond the usual measure, thicker layers of wood are deposited, more fruit is perfected, this ripens sooner, &c. The deposition of starch which occurs in the cells of the medullary rays in autumn,

goes to prove, that the portion of assimilated sap which is not used for nutrition on the way to the root, runs back to the wood through these horizontal medullary rays; and thus the sap describes a kind of circle, not, indeed, in determinate vessels, but in a definite path leading through the different parts of the plant. It is difficult to conceive how in recent times the results of these experiments could have been questioned, and the existence of the descending current in the bark denied. Certainly it is no improvement on the theory cast aside, when the increased growth above the annular wound is explained by the artificial interruption of the upward current of crude sap, in consequence of which the sap contained in the upper part of the plant must soon become greatly concentrated and potential for development (Schleiden, *Grundzuge*, 2d ed., ii, 513). When we can succeed in fattening an animal by depriving it of a portion of its accustomed food, this explanation may be received as satisfactory." (p. 70, 71.) After some excellent points of criticism, Mohl concludes that the discovery of endosmose has not fully solved the problem of the movement of the sap in plants, although in all probability it does play an important, and perhaps the principal part in its absorption and conveyance. (p. 77.) To the question, whether plants live on inorganic food alone, or take in also organic matters, Mohl gives a sensible answer, rejecting the extreme view of Liebig, while still fully recognizing the great office and result of vegetation. (p. 78.) According to Mohl, however, it is proved that plants do not absorb the carbonic acid dissolved in water with the latter by means of their roots, (p. 81); but this seems hardly reconcilable with several facts stated on the next page, from which it is justly concluded that carbonic acid is carried up with the ascending sap into the leaves. From the fact that plants perish so soon in air deprived of all oxygen gas, that sensitive leaves lose their irritability under such circumstances, &c., Mohl concludes, apparently with good reason, that the absorption of oxygen and the exhalation of carbonic acid in plants is a true physiological function, intimately connected with the life of the plant; and that this (rather than the opposite and predominant *nutrient* process, through which carbonic acid is decomposed and oxygen evolved) should be considered as the respiration of plants, if we use that term at all. (p. 86.) "The roots of plants, and not the leaves, take up the substances which furnish plants with nitrogen, while, on the contrary, the leaves play the essentially active part in the absorption of carbonic acid." (p. 88.) The analogy of the milky juice of plants to the blood of animals, as propounded by Schultz, is thoroughly refuted by our author, and the flowing movement in the milk vessels described by Schultz, is positively denied to take place in an uninjured plant, except as produced by mechanical causes. That the milky juice is not a nutrient material, still less the nutrient juice, is also manifest. (p. 96.)

The cell as an organ of propagation is treated, first as respects the multiplication of plants by division; second, by spores; and third, by seeds. The conjugation of certain Confervoid Algæ, such as Zygnema, is said to bear no analogy to sexual reproduction (p. 113); a conclusion which may be questioned. A good summary is given of the facts known respecting the free and spontaneous movements of the spores of

the lower Algæ (p. 115); and also of the recent discoveries respecting the bisexual reproduction of the higher Cryptogamia. The reprint of Henfrey's Report, in the January and March numbers of this Journal, has placed our readers *au courant* with the present state of knowledge on this interesting subject. It should be noticed that Mohl denies the existence of *antheridia* in lower Cryptogamia, or Thallophytes; but maintains that the small bodies, moving by two cilia, discovered by Decaisne and Thuret in the Fucaceæ, are more properly a second kind of spores, analogous to the small spores of the Florideæ, than of the nature of the seminal filaments of Ferns, Mosses, &c. (p. 117.) The later researches of Itzigsohn, Thuret, Tulasne, &c., however, lead rather to the conclusion that the lower Cryptogamia (except the very lowest) are likewise bisexual.*

* *Itzigsohn*, in *Botanische Zeitung*, May, 1850.—Here it is announced that the black dots on the surface of the frond of Borrera ciliaris contain antheridia, that is, cells from which escape animalcular-like corpuscles that move freely in water, and are similar to those of Mosses and Liverworts. Later, after stating that others had failed to detect these movements, he announces that they had been observed by Rabenhorst, after many ineffectual trials. He also (Dec. 1850, Feb. 1851) states that these "spermatozoids" do not manifest vital movements until after the maceration of the Lichen in water for several days.

Tulasne (L. R.), Mémoire pour servir à l'Histoire Organographique et Physiologique des Lichenes; in Ann. Sciences Naturelles, 3rd ser., xviii, No. 1, 2, 3, 4, (1852,) with 16 plates.—A most admirable and complete memoir, elucidating in an unequalled manner, the whole structure and morphology of the *Lichenes*. It is to be hoped that the author will publish it in a separate form; as it introduces a new era in Lichenography. On the subject of the so-called Antheridia (which alone we can here notice), M. Tulasne has recognized the universal occurrence of these bodies in Lichens, has ascertained their structure and development; but he has never detected any free movement of the corpuscles, except the general molecular or Brownian motion, common to all minute particles. He therefore gives to the so-called Antheridia the name of *spermogonia*, and to the contained corpuscles the name of *spermatia*. He unhesitatingly recognizes in them an apparatus of reproduction, doubtless analogous, at least in function, to those of the Florideous Algæ, in which the corpuscles are equally motionless, and of certain Fungi, and therefore probably representing male organs. Tulasne likewise calls attention to the fact that these dark tubercles or dots were particularly noticed by Dillenius, more than a century ago, in Borrera ciliaris; and that Hedwig, in 1784, expressed the opinion that they constituted the male apparatus of Lichens.

Decaisne & Thuret, Recherches sur les Anthéridies et les Spores de quelques Fucus; in Ann. Sci. Nat., 3rd ser., iii, p. 5.—Here the corpuscles known to the earlier Algologists, and considered by Agardh and Montagne as a second kind of spores (a view which Mohl adopts), are announced to be the spermatozoids of the antheridia of Fucaceæ; their active movements are described, and the discovery of the two cilia is announced by whose vibration the movement is effected.

Thuret, Recherches sur les zoospores des Algues et les Anthéridies des Cryptogames.—These researches were communicated to the Academy of Sciences, Paris, and were rewarded by the great prize for natural sciences, in 1847. A copious abstract has been published in the *Ann. Sci. Nat.*, 3rd ser., xiv, and xvi, (1850, 1851,) with 30 plates. As to antheridia, bodies like the free-moving corpuscles of the Fucaceæ are shown likewise to occur in all the Florideæ, except that they do not exhibit spontaneous movements; nevertheless, M. Thuret does not hesitate to attribute to both the same functions as those which the seminal filaments of the higher Cryptogamia fulfill. The Antheridia of Chara (in which Thuret first discovered the cilia by whose vibration the coiled filaments are moved), of the Liverworts, Mosses, and Ferns, are also admirably illustrated; but nothing of consequence is added to the facts mentioned in Henfrey's Report.

Léveillé, in Ann. Sci. Nat., 3rd ser., 15, p. 119, has indicated the probable existence of the analogues of antheridia in Fungi.

Under the head of Reproduction by Seeds, Mohl gives an interesting and critical account of the development and structure of the pollen and the ovule, and of the origin of the embryo. The latter arises by cell-multiplication of the germinal vesicle, a cell produced by free cell-formation in the embryo-sac usually before the pollen-tube has reached the latter. The germinal vesicle and the extremity of the pollen-tube are separated by the thickness of the parieties of the embryo-sac. The penetration of the pollen-tube into the latter, or into an introverted portion of it, and the formation of the embryo from the apex of the pollen-tube itself, as taught by Schleiden, are wholly repudiated; and indeed the Schleidenian doctrine may now be considered as thoroughly demolished, by the direct observations of Amici, Mohl, Muller, Hofmeister, Unger, Henfrey, and Tulasne.

The Cell as an Organ of Motion is considered as respects movements of individual cells through the agency of vibratile cilia, as respects the directions and curvature assumed by organs, and as respects movements by irritation of stimuli, &c., giving an excellent summary of our knowledge on these points, with much admirable criticism; which want of space prevents us from noticing in detail. Our notice will have served its purpose if it direct attention to a treatise, small in compass and moderate in price, but of the highest authority on these subjects of common interest to all naturalists and physiologists. Mr. Henfrey's name is a sufficient voucher for the faithfulness of the translation. But, with equal correctness, the German might have been rendered into more flowing and idiomatic English. A. G.

2. *Dr. Hooker's Flora of New Zealand.*—The third part, which has now appeared, carries this work from the Ericaceæ to the Orchidaceæ, and the plates from pl. 41 to 60. A. G.

3. *The Oak-Vegetation of America, (Americas Ege-vegetation, &c.) abridged from two popular lectures delivered before the Association of Natural History of Copenhagen*, by Prof. Liebman. Translated by Dr. Wallich.—This is reproduced in Hooker's Journal of Botany for Dec. and January last, and is a very interesting article, especially that part of it which relates to the oaks of Mexico, where the author travelled and collected extensively. Prof. Liebmann is now, we believe, the successor of Prof. Schouw, the celebrated writer on the Geography of Plants, of whose lamented decease we have recent intelligence. A. G.

4. *Martius, Flora Braziliensis*, Fasc. XI, Liepsic, 1852, pp. 75, fol., with 24 plates. This new part of the Brazilian flora, the publication of which is again actively resumed, contains the *Piperineæ*, a class which is here made to include the *Chloranthaceæ* and the *Piperaceæ*, but not the *Saururaceæ*. Both are elaborated by Prof. Miquel of Amsterdam, the indefatigable monographer of the latter family. The order Chloranthaceæ is represented in Brazil by a single species of *Hedyosmum*. Exclusive of Piper nigrum, which is a cultivated plant, the Brazilian Piperaceæ belong to six genera, namely, *Peperomia*, 53 species; *Pothomorphe*, 4 species; *Enckea*, 4 species; *Peltobryon*, 5 species; *Artanthe*, 80 species; *Ottonia*, 19 species. Besides the illustrations of this family, a single physiognomical plate represents a scene in the primæval forests of Brazil. A. G.

V. Astronomy.

1. *New Comet*, (Astron. Journal, No. 54.)—A telescopic comet was discovered near star 63 in the Constellation *Eridanus*, March 8, 1853, by Mr. Chas. W. Tuttle, assistant at Harvard College Observatory.

2. *Thalia*, (Astron. Jour., No. 55.)—The following elements of this planet have been communicated by W. Oeltzen of Vienna. They are computed from observations at Liverpool Dec. 16, Berlin Dec. 29, and Hamburg, Jan. 11.

Epoch, 1852, December 29·37907, m. t. Greenwich.

Mean anomaly, - -	324° 30′ 35″·0	Mean Eqx. 1853·0.
Long. of asc. node, - -	67 52 42 ·0	
Inclination, - - -	10 19 27 ·0	
Angle between perih. and node,	54 44 27 ·7	
Angle of excentricity, -	12 31 26 ·1	
Log. of semi-axis major, -	0·212976	
" mean daily motion, -	2·930543	

3. *Fortuna*, (Astronom. Nachrichten, No. 836.)—The following elements were computed by Mr. Carl Bruhns from Berlin observations of Aug. 28, Sept. 27 and Oct. 27.

Epoch 1852, Sept. 27·354061.

Mean anomaly, - - - - -	325° 5′ 47″·7
" longitude, - - - - -	357 26 29 ·6
Long. of perihelion, - - - -	32 20 41 ·9
" asc. node, - - - -	211 16 57 ·6
Inclination, - - - - -	1 32 35 ·0
Angle of excentricity, - - - -	9 48 18 ·9
Log. of semi-axis major, - - -	0·390678
" mean daily motion, - - -	2·963990

4. *Parallax of a Star.*—In a previous No. of this Journal* it was stated that M. H. Faye, of Paris, had found for the parallax of an unnamed star in *Ursa Major* (1830 of Groombridge's Catalogue of Circumpolar Stars) 1″·06. M. Peters, on the contrary, made it only 0″·23; M. Wichmann, 0″·18; and M. Otto Struve, 0″·03. In these investigations it was assumed that the stars of comparison had no parallax. M. Wichmann has continued his labors upon this star, and the new results to which he has arrived are given in part in a letter to M. Faye; a part of which is here given in translation from the *Comptes Rendus* (tom. 35, p. 859, Dec. 13, 1852).

"During the past year I have made with the aid of the heliometer a new series of observations upon this star (1830 G.) using for comparison not only the stars selected by Schlueter, but also the star used by yourself. This last I designate by a'', and those of Schlueter by a and a'; (a' and a'' being situated upon one side of 1830 G. and a upon the

* 2d Series, vol. iii, p. 444.

opposite side.) The result of my researches may be expressed as follows:

1. The parallax of a'' is equal to that of a'.
2. The parallax of a is $1''{\cdot}17$ greater than that of a'.
3. The parallax of 1830 G. is $0''{\cdot}14$ greater than the arithmetical mean of the parallaxes of a and a'; i. e., it is $0''{\cdot}72$ greater than the parallax of a' or of a''.

Thus the mysterious discordance which before existed between the parallax obtained by you in 1846, and that given by the Königsberg heliometer is explained by the interesting fact that the star of comparison a is nearer to us than 1830 G. You know that my reduction of the observations made by M. Schlueter gave for the parallax of 1830 G. $0''{\cdot}18$, on the supposition that the stars of comparison had no parallax, a result obtained by the discussion of differences of distance. But in the sum of the distances, which should be constant, there was shown an annual and periodic change, whose cause was unknown. These results are confirmed by my new observations; the same annual variation is presented, in the same direction, and of the same amount. To explain this I have formed two hypotheses; one, that this variation in the sum of the distances is caused by the influence of temperature on the parts of the instrument; the other, that it results from a difference in the parallaxes of the stars of comparison. The last hypothesis represents the observations very well, without leaving periodic errors of much magnitude, while the first, even giving to the action of heat a value three to five times as great as that found by Bessel, cannot represent the observations, and it leaves residuary errors which are wholly improbable. Upon the second hypothesis the observations made by Schlueter accord remarkably well with mine. Supposing the parallax of the stars a' and $a''=0$, we have the parallaxes,

	Of 1830 G.	Of the star a.
By Schlueter's observations,	$=0''{\cdot}75$	$=1''{\cdot}15$
By my "	$=0''{\cdot}68$	$=1''{\cdot}19$

Or if we deny the difference of parallax of the stars of comparison, it will necessarily result from the observations made with the heliometer that the parallax of 1830 G. is less than $0''{\cdot}2$; for these observations are arranged in such a manner, as you will see in my memoir,* that the differences of distance and the consequent result are wholly free from the influence of the periodic change which is manifested in the sum of the distances, whatever may be the cause of it. The inevitable alternative is, that the parallax of 1830 G. is less than $0''{\cdot}2$, a value not at all probable, or that the star a is nearer to us than 1830 G. I have no doubt that the last, which is indicated by the observations, is the truth; and I believe this interesting result is established so surely by the heliometric measures, that it will be very difficult to prove that the large parallax of this star of comparison which I have found does not exist."

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* Astronomische Nachrichten, Nos. 840–844.

VI. Miscellaneous Intelligence.

1. *Meteorological Observations at Burlington, Vt.;* by Z. Thompson.—Mr. Thompson adds the following to his paper at p. 385. List of the appearances of the Aurora Borealis observed at Burlington in 1852:

Jan. 19, distinct arch and streamers; 21, part of an arch in the N. E.; 23, faint auroral light; 25, ibid.; 26, ibid.

Feb. 16, faint auroral light; 18, two distinct concentric arches, the vertex of one being about 8° and the other 18° high.

Feb. 19, very splendid aurora, appeared soon after sunset, at first in the form of an arch, spanning the heavens from N. W. to S. E. and passing 8° or 10° S. W. of the zenith, the northwestern position being strongly tinged with red and umber. At the vertex of the arch, there was the appearance of radiation. The meteor continued moving and flashing over the northern half of the heavens during the whole night, and was visible till nearly sunrise the next morning. 27, two distinct arches with streamers.

March 7. Meteor moderate—no distinct arch; 10, meteor faint; 16, aurora very bright but low in N.; 19, aurora borealis low in N.; 20, ibid.

April 8, aurora borealis faint; 13, aurora very bright in the N.; 14, ibid.; 17, faint; 20, ibid.

May 3, aurora borealis faint; 5, ibid.; 8, ibid.; 9, ibid.; 14, ibid.; 18, distinct arch.

June 11, aurora borealis very splendid—motions exceedingly rapid; 16, aurora glow with streamers.

July 5, aurora, with faint streamers; 12, auroral arch 15° in N. at 9 P. M.

Aug. 10, aurora borealis faint; 11, ibid. in N. E.

Sept. 6, aurora borealis broad arch—vertex of the under margin 11° high at 9 P. M., and well defined; 17, aurora arch about 8° high from 7 to 9 P. M.; 18, slight aurora borealis.

Oct. 5 and 6, slight aurora borealis.

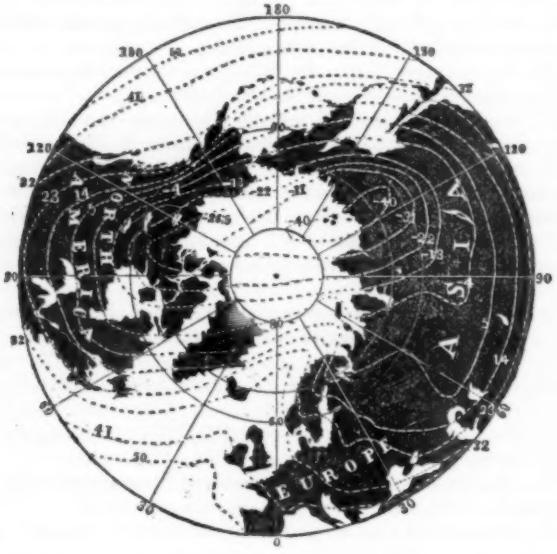
Nov. 11, splendid aurora borealis from 7 to 9 P. M. At 8¾h. two arches, one 15° and the other 30° high under the N. pole, with short streamers under the lower arch. At 9, very bright streamers in N. E., arches not well defined; 19, slight aurora in N. E.

Dec. 8, slight aurora in N. E.

2. *Chart of Isothermal Lines.*—A chart of isothermal lines accompanies this volume, illustrative of Mr. W. Hopkins's paper on Changes of Climate, especially the part from pages 72 to 86. This chart is from Dove's Isothermal Charts, the upper half being copied from his chart for January, and the lower half from that for July; and it is thus a winter chart throughout. The lines mark degrees of Fahrenheit. Those north of the equator are 77°, 68°, 59°, 50°, 41°, 32°, 23°, 14°, 5°, —4°, —13°, —22°, —26°·5, —31°, —40°, differing thus 9° Fahrenheit (equivalent to 4° Reaumur or 5° Centigrade). The line of 77° passes through those points which have 77° for the mean temperature for January; and so on. South of the equator, the lines are the same, but are twice nearer, the temperatures differing by 4½° F.

On the annexed cut, also copied, of reduced size, from Dove, the same lines north of the equator are shown on a north pole view of the globe; it exhibits the region of greatest cold about northern Asia.

Many deductions flow from such a chart. We allude only to one in this place. To the north, on the parallel of 60°, the mean temperature



of the earth varies from $-26\frac{1}{2}°$ F. (in northern America) to $-13°$, $-4°$, $+5°$, $+14°$, $+23°$, $+39°$, $+40°$ (in the northern Atlantic); then decreases again regularly to $-40°$, the intense cold of northern Asia; and then again increases to $+23°$. Such a wide variation of temperature on the same parallel, contrasts strikingly with the near uniformity along the line of 60° south; and it suggests reasons for electrical and other meteorological disturbances on a grand scale at the north, which can have no parallel at the south.

3. *Belcher's Artesian Well, in St. Louis*, (from the St. Louis Republican.)—Allusion was made a few days since to the progress of the Artesian well that Mr. Wm. H. Belcher is sinking in the upper part of the city to supply his extensive sugar refinery with other than limestone water, which only can be found by the ordinary channels in this vicinity. The well, which we think was commenced early in the year 1849, has now attained the great depth of 1590 feet. The boring still progresses without intermission, night and day, the hands, six in number, relieving one another by regular watches. The iron "sinker," with which the drilling is effected, is 34 feet in length, $2\frac{1}{2}$ inches in diameter, and between 700 and 800 pounds in weight. It is attached to poles, severally about 30 feet long, that are screwed to each other to extend to the full depth of the well. The whole is moved by a "doctor," worked by the boilers used for the refinery engines. Sev-

eral veins of impure water have been struck in the course of the excavation, to rid the well of which, a pump, also worked by the "doctor," is constantly in operation. At the present depth of 1590 feet a pretty copious stream of sulphur water issues from the well. The water has the taste precisely of the Blue Lick water in Kentucky, though perhaps not quite so strongly impregnated with sulphur. We have obtained from the gentleman who superintends the boring, an exhibit of the different strata through which he has passed. The statement possesses sufficient interest for publication:

1st, Through limestone, 28 feet; 2d, shale 2; 3d, limestone 231; 4th, cherty rock 15; 5th, limestone 74; 6th, shale 30; 7th, limestone 75; 8th, shale 1½; 9th, limestone 38½; 10th, sandy shale 6½; 11th, limestone 128½; 12th, red marl 15; 13th, shale 30; 14th, red marl 50; 15th, shale 30; 16th, limestone 119; 17th, shale 66; 18th, bituminous marl 15; 19th, shale 80; 20th, limestone 134; 21st, cherty rock 62; 22d, limestone 138; 23d, shale 70; 24th, limestone 20; 25th, shale 56; 26th, limestone 34; white soft sandstone 15 feet.

The well was first commenced, we understand, as a cistern. From the surface of the ground, where it is fourteen feet in diameter, it has a conical form, lessening at the depth of thirty feet to a diameter of six feet. Thence the diameter is again lessened to sixteen inches, until the depth of 78 feet from the surface is attained. From that point it is diminished to nine inches, and this diameter is preserved to the depth of 457 feet. Passing this line the diameter to the present bottom of the well, is three and a half inches.

The lowest summer stand of the Mississippi river is passed in the first strata of shale, at a depth of twenty-nine or thirty feet from the surface. The water in the well, however, is always higher than the water line of the river, and is not affected by the variations of the latter. The first appearance of gas was found at a depth of 466 feet, in a stratum of shale one and a half feet thick, which was strongly imbued with carbonated hydrogen. When about 520 feet below the surface of the earth, at the beginning of a layer of limestone, the water in the well became salty. The level of the sea—reckoned to be five hundred and thirty-two feet below the city of St. Louis—was passed farther in the same layer; two hundred feet lower still, in a bed of shale, the water contained 1⅞ per cent. of salt. At a depth of 950 feet a bed of bituminous marl, 15 feet in diameter, was struck. The marl nearly resembled coal, and on being subjected to great heat, without actually burning, lost much of its weight. In the stratum of shale which followed, the salt in the water increased to 2¼ per cent. The hardest rock passed, was a bed of chert, struck at a depth of 1179 feet from the surface, and going down 62 feet. In this layer, the salt in the water increased to full three per cent. The boring at present, is, as appears by the statement above, in a bed of white soft sandstone, the most promising that has yet been struck for a supply of water, such as is wanted.

Observations have been made with a Celsius thermometer of the temperature of the well. At the mouth of the orifice, the thermometer marks 50 degrees; at the depth of 45 feet, the heat is regular, neither increasing nor diminishing with the variations above, and at the distance of 1351 feet, the heat has increased to 69 degrees.

The Artesian well of Mr. Belcher is already one of the deepest in this country; it is considerably more than half the depth of the celebrated Artesian well in Westphalia, Germany, which is sunk 2,385 feet. If the recent indications do not deceive, a supply of sweet pure water will be soon obtained.

4. *Washington Territory.*—Among the few acts of positive legislation consummated at the Session of Congress just concluded, that organizing the new *Territory of Washington* is one of the most important and interesting.

"Washington Territory" (so named with singular inappropriateness, and, contributing fresh confusion to our already confused nomenclature) comprises the northern portion of the recent Oregon Territory, and is bounded on the south by the Columbia river, up to near Fort Walla-Walla, (some two hundred and ninety miles,) where the parallel of 46° of latitude intersects it; thence by this parallel to the crest of the Rocky Mountains; thence the boundary follows this mountain crest to latitude 49°, and thence runs west on this parallel to the Gulf of Georgia and the Straits of de Fuca to the Pacific, by which it is limited on the west. We derive from a scientific and well-informed source some particulars respecting this Territory, not readily accessible to the public, which we present to our readers.

"Washington Territory" lies chiefly between latitudes 46° and 49° and between longitudes 110° and 125° west of Greenwich. The boundary initial points and parallels must soon be accurately determined, and it must be decided where the crest of the Rocky Mountains really is. This latter problem may not be easy of solution, for Lewis & Clark, Father de Smet, the Irving Astoria Map, and the Indian Bureau and Topograpical Bureau maps all represent these mountains differently. Lewis & Clark exhibit four distinct ranges, with which the best recent explorations essentially agree; indicating at least three parallel ranges running nearly northwest, instead of the more prevalent indication of a single north and south range. Exploration may show the necessity of a more definite eastern boundary. On the north the mouth of Frazer's river is so near to latitude 49° that a portion of it may be found to fall in the United States, though this is improbable. There are thus several important geographical questions connected with the boundaries of this neophyte State.

"Washington Territory" has within its limits portions as well explored and others as nearly unknown as can be found west of the Mississippi. The Columbia river was thoroughly surveyed by Capt. Wilkes, two sheets out of six being now published. It was surveyed by Belcher, in 1839, and two sheets are published among the Admiralty charts. The Coast Survey has twice surveyed its mouth, and published one sheet. A comparison of these several surveys with Vancouver's indicates a remarkable degree of shifting in the sand-banks at its mouth. Shoalwater Bay has been surveyed by the Coast Survey, but the survey is not published. Grey's Harbor has also been just surveyed, and this, with Chickalees river, has been surveyed, and the survey published by Capt. Wilkes. The Admiralty charts cover the Straits of de Fuca and many harbors on the mainland and on Vancouver's Island. A Coast Survey reconnoissance has now extended up the en-

tire Pacific coast and along the south coast of the Straits of de Fuca, and will soon be published. The surveys under Captain Wilkes and his narrative give full information of all the groups of islands in the Gulf of Georgia, and the channels leading to and making up Puget's Sound, with much detail. The shores of this wonderful network of channels are so favored in soil and location that they must soon possess great value. Through a surprising extent of line they are directly accessible for ocean vessels, and form, as it were, an immense network of harbor. They present the foundation for a kind of agricultural Venice, far into the heart of the west half of Washington, the resources of which they will greatly aid in developing. Fort Nisqually and Olympia, at the southern extremity of Puget's Sound, must rapidly advance with the growth of the Territory.

The interior portion of this section is but imperfectly known. The land office surveys north of the Columbia have as yet made little progress; but the sketches prepared in that office give more recent and correct information than is elsewhere to be found on the section between that river and Puget's Sound. On penetrating farther towards the Rocky Mountains, the country is essentially unknown. The narrative of Lewis and Clark, the book on Oregon Missions, by Father de Smet, published in New York in 1847, and Irving's Astoria (the last edition) are the chief publications of value on this ground. These serve merely to show that the country bordering the Rocky Mountains between 46° and 49°, on both sides, is still a good field for exploration. Much may be expected from Dr. Evans, who is engaged in a geological reconnoissance of the old Oregon Territory, which has taken him much among the Rocky Mountains, and over their basal plains.

With a field every way so requiring examination, it is fortunate that the newly-appointed Governor of Washington possesses so many peculiar qualifications for his station, and especially a thorough training in geographical science. Gov. STEVENS, late a Lieutenant and Brevet Major of the Corps of Engineers, and now just entering on his duties as Governor of "Washington Territory," has been the Assistant in charge of the Coast Survey Office for over three years. A head graduate at West Point, a highly efficient constructing officer of Engineers, distinguished on Gen. Scott's staff in Mexico, he has discharged the laborious and difficult administrative duties of his recent position in so excellent a manner as to elicit frequent encomiums from Professor Bache, the Superintendent of the Coast Survey, and to afford every guarantee that he will make himself most usefully felt in the sphere on which he is entering. We expect, from his energy, from his liberality of views and attainments, that he will not permit his present term to expire without presenting to the public a tolerably complete map of the Territory, and such reports as will give a clear conception of the surface, soil, resources, products, and peculiarities of a region, so soon to become a State with a voice in our National Councils. Those who best know him are confident he will be able to accomplish this, and much more, in addition to those important and laborious duties which will devolve on him in organizing and putting into thorough operation the machinery of a new Territorial Government. H.

OBITUARY.

Anthony D. Stanley, Professor of Mathematics in Yale College, died on the 16th of March, aged 43 years. Mr. Stanley held the office of Tutor in Yale College from 1832 to 1836, when he was appointed Professor of Mathematics; and after two years in Europe, he entered upon his new duties in 1838. From that period to 1849, he pursued the life of a faithful teacher and was besides untiring in his studies and investigations. His principal contribution to this Journal appeared in the third volume (1847). He published also an elementary Treatise on Spherical Geometry and Trigonometry, and a volume of Logarithmic and other Mathematical Tables. The latter work was one of vast labor, as he undertook the thorough revision of existing tables; and in the course of it he detected several errors in the tables of Callet, Vega, Babbage and Shortrede. The work was printed with extreme care, and but two errors have yet been pointed out. A severe cold, taken in 1849, ended finally in settled consumption, from which he found but partial relief in a visit during 1850 to Egypt and Syria. After his return he resumed for a while his duties in college, but soon left them and retired to his home in East Hartford, where he died. Prof. Stanley was a man of deep devotion to his favorite pursuit, of great ability and accuracy in research, and of the highest moral worth. A natural diffidence and reserve led him to withhold from publication much that would have proved an honor to himself and of value to science.

Von Buch.—This eminent geologist died at Berlin, on the 4th of March, aged 79 years. The following is a letter from Humboldt to Sir R. I. Murchison, announcing his death, (Athenæum, No 1324).

"That I should be destined—I, an old man of eighty-three—to announce to you, dear Sir Roderick, the saddest news that I could have to convey:—to you for whom M. de Buch professed a friendship so tender, and to the many admirers of his genius, his vast labors, and his noble character! Leopold De Buch was taken from us this morning by typhoid fever, so violent in its attack that two days only of danger warned us. He was at my house so lately as the 26th [ult.], despite the snow and the distance between us, talking geology with the most lively interest. That evening he went into society; and on Sunday and Monday (the 27th and 28th) he complained of a feverish attack, which he believed to be caused by a large chilblain swelling from which he had suffered for years. The inflammation required the application of leeches, but the pain and the fever increased. He was speechless for thirty-eight hours. * * He died surrounded by his friends,—most of whom knew nothing of his danger till Wednesday evening, the 2d of March.

"He and I were united by a friendship of sixty-three years,—a friendship which never knew interruption. I found him in 1791, in Werner's house in Freiburg, when I entered the School of Mines. We were together in Italy, in Switzerland, in France,—four months in Saltzburg. M. De Buch was not only one of the great illustrations of his age,—he was a man of noble soul. His mind left a track of light wherever it passed. Always in contact with Nature herself, he could well boast of having extended the limits of geological science. I grieve for him profoundly,—without him I feel desolate. I consulted him as

a master; and his affection (like that of Gay Lussac and that of Arago who were also his friends) sustained me in my labors. He was four years my junior,—and nothing forewarned me of this misfortune. It is not at the distance of a few hours only from such a loss, that I can say more respecting it. Pity me,—and accept the homage of my profound respect and affectionate devotion."

VII. Bibliography.

1. *Cosmography or Philosophical Views of the Universe;* by Charles F. Winslow, M.D. 174 pp. 16mo. Boston, 1853. Crosby and Nichols.—This volume treats in Part I, of the "Development of the Theory of Repulsion as a Planetary, Solar and Universal Force;" Part II, includes an application of the Theory of Repulsion to the Creation of the Universe; Part III, treats of the "Inequalities of Surface in the solid spheres and the successive Revolutions observed throughout the Crust of our Globe, as Results of the Alternating Intensity of Cosmical Forces." The views are in a few points novel, but our own opinions are quite at variance with the author's conclusions.

2. *Handbook of Universal Geography*, being a Gazetteer of the World. Edited by T. Carey Callicot, A.M. 856 pp. 12mo. New York, 1853. G. P. Putnam & Co. A very excellent Gazetteer, embracing a large compass with great fullness. The notices of places are brief, and by this means it is rendered wonderfully comprehensive, considering the size of the work.

3. *Elements of Geology;* by Alonzo Gray, A.M., author of Elements of Chemistry and Elements of Natural Philosophy, and C. B. Adams, A.M., Fellow of the Amer. Acad. of Arts and Sciences, Prof. in Amherst College, &c. 354 pp. 12mo. 1853. Harper & Brothers. —This work is a brief review of the elements of Geology, prepared for instruction in Schools and Colleges. It commences with an account of the various agencies employed in producing changes in the earth's surface, inorganic and organic, and thence proceeds to the arrangement, structure and historical relations of the earth's strata. It is illustrated by many wood-cuts.

4. *Catalogue of North American Reptiles in the Museum of the Smithsonian Institution.* Part I. SERPENTS: by S. F. Baird and C. Girard. Washington: Smithsonian Institution. 172 pp. 8vo. Jan., 1853.—Although styled a Catalogue, this volume contains descriptions of many new genera and species, with extended original observations.

5. *Annual Report of the Superintendent of the Coast Survey*, showing the progress of that work, during the year ending November, 1851. 558 pp. 8vo. Washington, 1852, 32d Congress, 1st session, Ex. Doc. No. 3.—We have already cited from this able Report the report of G. Mathiot on Electrotyping as employed by the Coast Survey.

6. *A Synopsis or Systematic Catalogue of the Medicinal Plants of the United States;* by A. Clapp, M.D. 222 pp. 8vo. Philadelphia, 1852. Presented to the American Medical Association, at its session in May, 1852.—This catalogue by Dr. Clapp has been prepared with much care, and contains notes both medical and historical, which add greatly to its interest and value.

7. *Natural History of New York: Palæontology*, vol. ii, by JAMES HALL. 362 pp. 4to, with 102 plates. We take special pleasure in announcing the publication of this very valuable volume, the second on the Palæontology of New York, by Mr. Hall. The plates are beautifully executed, and the whole is an honor to the country as well as to the State under whose auspices it is published.

8. *Journal of the Academy of Natural Sciences*, [2], ii. Part III. pp. 185–276, with plates 17 to 24, 4to. Philadelphia, January, 1853.

Art. XX. ISAAC LEA: Description of a Fossil Saurian of the New Red Sandstone Formation of Pennsylvania; with some account of that Formation.

XXI. ISAAC LEA: On some New Fossil Molluscs in the Carboniferous Slates of the Anthracite Seams of the Wilkesbarre Coal Formation.

XXII. J. LEIDY: On the Osteology of the head of Hippopotamus, and a description of the Osteological Characters of a new genus of Hippopotamidæ.

XXIII. J. L. LE CONTE: Synopsis of the species of Pterostichus Bon. and allied genera inhabiting temperate North America.

XXIV. J. CASSIN: Description of new species of Birds of the genera Melanerpes, Swainson, and Lanius, Linnæus.

XXV. A. L. HEERMANN: Notes on the Birds of California, observed during a residence of three years in that country.

XXVI. T. A. CONRAD: Descriptions of New Fossil Shells of the United States.

9. *Crustacea of the U. S. Exploring Expedition under Capt. C. Wilkes;* by JAMES D. DANA. 4to. Part I, including 680 pages, was published in December last. Part II, the conclusion of the work, embracing 940 pages, will appear the coming month. The plates will be longer delayed; they will make a large folio volume of 96 plates, partly colored. We defer a farther notice to our next.

JAPAN, an account Geographical and Historical; by Charles MacFarlane, Esq., author of British India, &c. 365 pp. 12mo, with numerous illustrations. *New York*, 1852. G. P. Putnam & Co.

BRIEF ASTRONOMICAL TABLES conducted on a simple Plan for the Expeditious Calculation of Eclipses in all ages, designed for the purpose of verifying dates. (The subject of a Paper read before the Isle of Wight Philosophical and Scientific Society on March 1st, 1852.) By W. Drew Snooke, Prof. Math. and Astronomy. 32 pp. 8vo. *London*, 1852. S. Highley & Son, 32 Fleet Street. 2*s.* 6*d.*

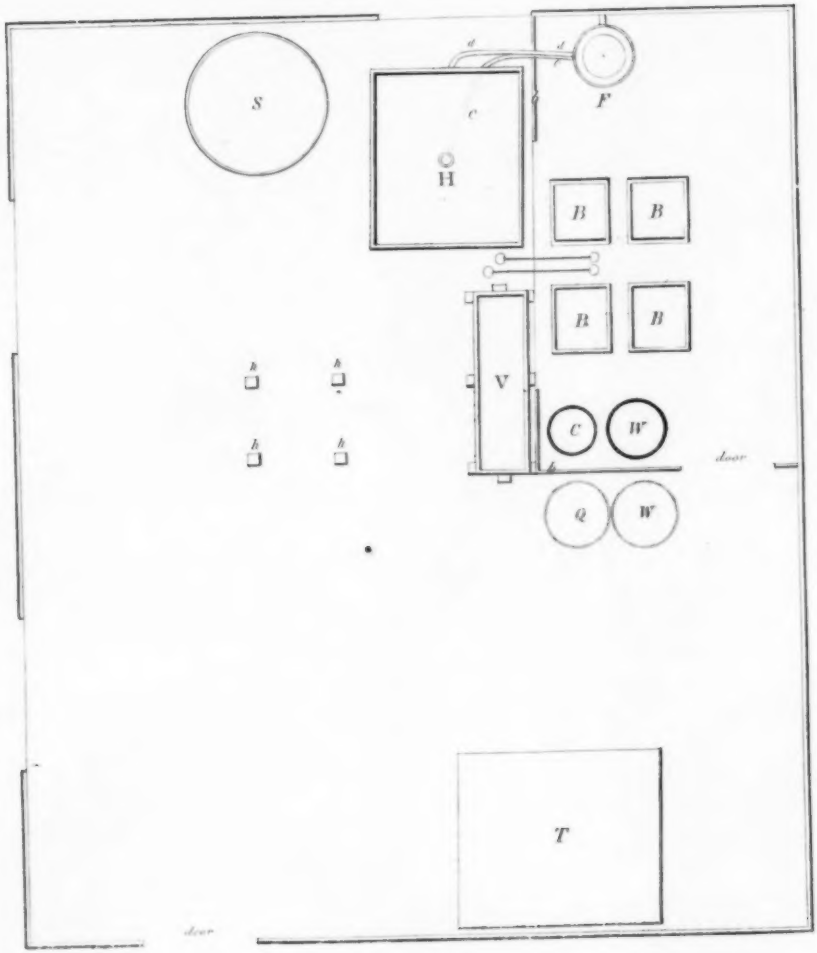
PROCEEDINGS ACAD. NAT. SCI. PHILADELPHIA, vol. vi, No. vii, 1853.—p. 224. Remarks on the genus Dipodomys; *J. L. Le Conte.*—p. 226. Descriptions of twenty new species of U. S. Coleoptera; *J. L. Le Conte.*—p. 235. Description of a new species of Pouched Rat, of the genus Dipodomys, (D. Ordii); *S. W. Woodhouse.*—p. 236. New Reptiles from California; *E. Hallowell.*—p. 242. A new Mouse of the genus Hesperomys; *S. W. Woodhouse.*—p. 243. Synopsis of the Family of Naiades of North America, and a Table of some of the genera and subgenera of the Family according to their geographical distribution, and descriptions of genera and subgenera; *T. A. Conrad.*—p. 269. An enumeration of the Vines of North America, by J. L. Le Conte, F.L.S.—p. 274. Synopsis of the Silphales of America, and North of Mexico; *J. L. Le Conte.*—p. 287. Synopsis of the species of the Histeroid genus *Abræus*, Leach, inhabiting the United States, with descriptions of two nearly allied new genera; *J. L. Le Conte.*—p. 292. Chemical examination of remains of Fossil Mammalia; *F. V. Greene.*—p. 296. On a new variety of Gray Copper, perhaps a new mineral; *Dr. F. A. Genth.*—p. 297. On Owenite, a new mineral; *Dr. F. A. Genth.*—p. 299. On a new species of Scalops; *J. Cassin.*—p. 300. List of Reptiles collected in California by J. L. Le Conte; *S. F. Baird* and *C. Girard.*

Fig. 1

Plan of the Laboratory

Showing the arrangement of the Electrotype Apparatus

in the U. S. Coast Survey Office.



Scale 1 inch to 4 feet

rey. A. D. Bache, Superintendent.
f the Electrotype Department U. S. Coast Survey Office
1851

Fig. 2

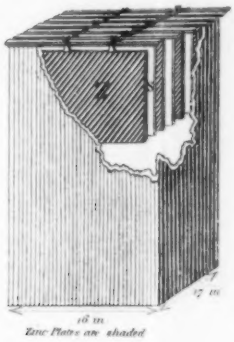
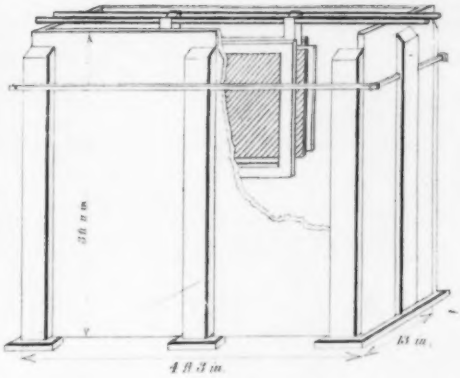


Fig. 4



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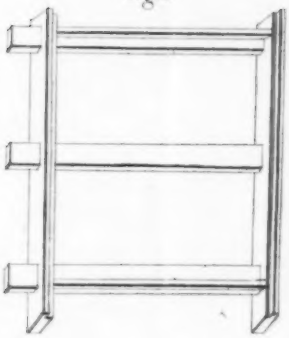

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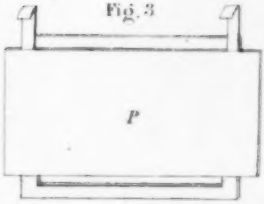


Fig. 7

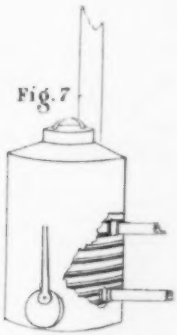
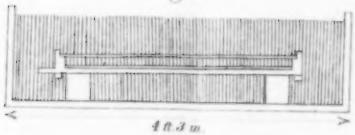
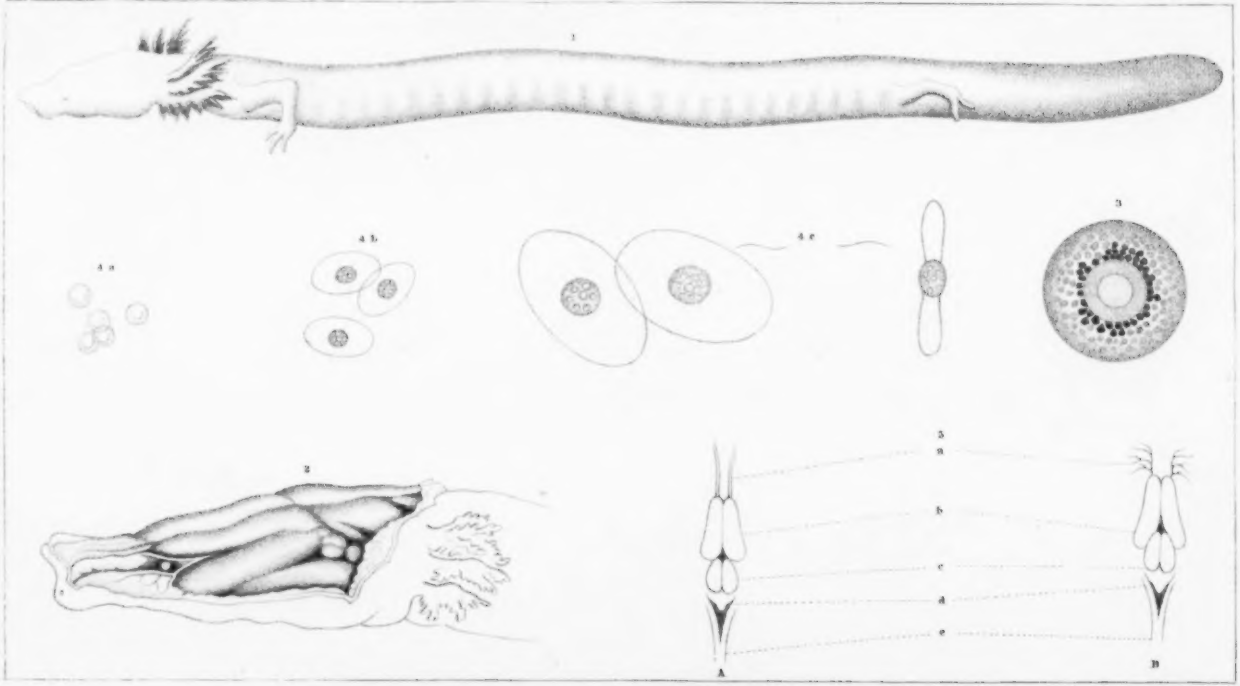


Fig. 6





PROTEUS ANGUINUS.

Index photographed at the
beginning for the convenience
of the microfilm user.